HELSINKI SCHOOL OF ECONOMICS
Department of Economics

FAST ACCUMULATION OF FOREIGN EXCHANGE RESERVES IN EMERGING ASIA
– REASONS FOR HIGHER DEMAND IN THE 21ST CENTURY

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Tutkimuksen tavoite
Tämän tutkimuksen tavoitteena on selvittää syitä Aasian kehittyvien talouksien kasvaneeseen ulkomaisten valuuttavarantojen kysyntään 2000-luvulla. Vaikka maailma on enenevissä määrin siirtynyt kelluvien kurssien aikakauteen, keskuspankit etenkin Aasiassa ovat viime vuosina kerryttäneet ulkomaisia valuuttavarantojaan ennennäkemätöntä vauhtia. Tarkoituksena on tutkia motiivien muuttumista valuuttavarantojen kasvattamisen taustalla sekä selvittää, missä on varantojen optimaalinen taso.

Tutkimuksen toteutustapa, menetelmät ja aineistot
Lähestyn tutkimusongelmaa ensin teoreettisesti tutkimusten ja työpapereiden pohjalta, ja sen jälkeen empiirisesti tutkimalla Kiinan, Korean ja Taiwanin taloudessa tapahtuneita muutoksia vuosina 1990–2006. Regressioanalyysin avulla tarkastelen syiden kehitystä valuuttavarantojen kasvun taustalla, ja jatkan tutkimusta olemassa olevien mallien pohjalta laskemalla Kiinalle, Korealle ja Taiwanille aiheutuneet kustannukset valuuttavarannoista vuosilta 2004–2007 sekä niille optimaaliset valuuttavarantojen tasot. Aineistona käytän sekä Kiinan, Korean ja Taiwanin keskuspankkien, kuin myös suurimpien kansainvälisten organisaatioiden (Kansainvälinen valuuttarahasto IMF, Maailman pankki, OECD, Aasian kehityspankki) tilastoja ja datapankkeja.

Tutkimuksen tulokset
Tutkimuksen teoreettinen viitekehys sekä Kiinasta, Koreasta ja Taiwanista lasketut ekonometriset tulokset osoittavat, että valuuttavarantojen kerryttämisen syyt ovat muuttuneet Aasian talouskriisin jälkeen, eikä klassisilla selitystekijöillä enää pystytä ennustamaan varantojen kehitystä. Lisäksi aiemmista regressioanalyyseistä poiketen käyttämäni maakohtainen tarkastelu paljastaa paremmin selittäviä tekijöitä varantojen kerryttämiselle. Varannoista aiheutuvat kustannukset vievät suhteessa suuren osan vuotuisesta bruttokansantuotteesta, ja optimaalinen taso näyttäisi jäävän yhä kauemmas taakse.

Avainsanat
Ulkomaiset valuuttavarannot, Aasia, kehittyvät taloudet, valuuttakurssit, Kiina, Korea, Taiwan

HELSINKI SCHOOL OF ECONOMICS **ABSTRACT**
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FAST ACCUMULATION OF FOREIGN EXCHANGE RESERVES IN EMERGING ASIA -REASONS FOR HIGHER DEMAND IN THE 21ST CENTURY

Aim of research
The aim of this research is to find reasons for Asian emerging economies' higher demand for foreign exchange reserves in the 21st century. Even though the world is marching steadily towards freely floating exchange rates, central banks especially in Asia have been accumulating foreign exchange on their balance sheets at an unparalleled pace. The aim is to study the development of motives behind the hoarding and to define the optimal level of reserves in Asian emerging economies at present by examining in more details China, South Korea and Taiwan.

Research methods and data
I am approaching the research problem first through theory and models from working papers and studies. Second, I conduct an empirical analysis on China, South Korea, and Taiwan examining their economic development since 1990. With multiple regression analysis I consider the change in motives behind the foreign exchange reserves growth, and continue the research by calculating the costs this accumulation is inflicting on China, South Korea, and Taiwan at present (2004-2007) as well as the optimal levels for reserves. Data is being gathered from central banks of China, South Korea and Taiwan, and from international organizations' statistic databases (International Monetary Fund IMF, World Bank, Asian Development Bank ADB, OECD).

Results
The theoretical framework and the empirical findings from China, South Korea and Taiwan both prove that the motives behind the fast accumulation of foreign exchange reserves in emerging Asia have in fact altered after the Asian crisis. The classic explanatory variables can no longer accurately forecast the development of reserve accumulation. In addition, this country-specific regression analysis enables to reveal motives better than broad country coverage where details on individual country cases may get lost, and is therefore a useful extension of global examinations conducted earlier. Fiscal costs from reserves are being substantial measured as share of annual GDP, and the optimal level seems to be falling further behind.

Key words
Foreign exchange reserves, Asia, emerging economies, exchange rates, China, Korea, Taiwan

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1. Introduction

How do large foreign exchange reserves affect country's economic situation and how necessary or needful it is to accumulate them in such pace never witnessed before? Albeit the world today is moving gradually towards flexible exchange rates, monetary authorities' balance sheets are still glutted with foreign exchange, mostly U.S. dollars. Relatively even much more so than in the days of regulated monetary management when foreign exchange was needed to maintain appropriate rates. Are foreign exchange reserves at present well above their optimum level? What makes countries to follow such costly strategy especially in emerging economies, and how do they come off?

1.1 Purpose of the Thesis

Large foreign exchange reserves have become reality in emerging markets all around the world. Especially transition economies in Asia have started to accumulate strong liquidity reserves on their central bank balance sheets.

Biggest country to accumulate foreign exchange reserves and who in that way also plays leader role in affecting world economies is China. While most of its foreign exchange reserves (worth over 1500 billion dollars in January 2008) are being held in form of U.S. Treasury bonds, China's decisions have an inevitable impact on U.S. economy. It is being widely debated in public what might be the reasons for China to act upon such strategy, and in what extent its behaviour is distorting free markets.

The idea behind my Master's Thesis is however not to focus on assessing implications large foreign exchange reserves might have for the United States and rest of the developed world through foreign trade, but to think about ways reserve accumulation contributes to macroeconomic aggregates that affect transition economies themselves. As Dani Rodrick (2006) calculated, holding large foreign exchange reserves cost a country about 1 % of its annual GDP (see chapter 5.2.1), and from that point of view, it wouldn't seem rational for

still developing countries to waste such huge sums of money every year if it wouldn't bring any positive contribution.

There have been papers written and research work done about costs and implications foreign exchange reserves could inflict in domestic economies. Researchers have empirically assessed costs and benefits and adequate levels of reserves (Hauner, 2005; IMF, 2003; Dooley, Falkerts-Landau & Garber, 2003; Lane & Burke, 2001). I am going to examine how large foreign exchange reserves have changed the overall economic situation Asian emerging economies are facing today by studying in more detail China, South Korea and Taiwan. These three countries have been growing fast and hoarding foreign exchange reserves faster than other countries, especially after the Asian crisis that broke out in 1997. Thus they also face the largest expenses for holding massive reserves and it must implicate that at least some benefits are being gained. I am trying to detect differences in countries' economic indicators when comparing time prior to 1997 in contrast to the recent era of growth. The distinction between these two periods of economic success is indeed the lack of foreign exchange reserves at the beginning of the 1990's.

I am going to further introduce theories and calculations researchers have been doing in recent years in order to model the necessity of large foreign exchange reserves in a world of more floating exchange rates, and estimations about optimal reserve levels (Rodrik, 2006; Aizenman & Lee, 2005; Hauner, 2005; García & Soto, 2004). With my own multiple linear regression models, I try to find reasons related to large foreign exchange reserves and especially if the motive for accumulation has altered throughout recent times. I am further calculating the fiscal costs resulting from this accumulation in China, South Korea, and Taiwan from recent years (2004-2007) and assessing the reasonability of larger reserves.

1.2 Background

First working papers, studies and reviews of the literature of foreign exchange reserves (from now on I refer to them also as FER) were written in the 1960's and 70's, when FER were starting to play a role in international economics (for ex. Clark (1970), Clower & Lipsey (1968) and Gourchene & Youssef (1967)). They dealt with the demand for international liquidity and adequacy of its volume.

At that time industrial states operated under the Bretton Woods system. Main implication of the system agreed upon by 44 independent nation-states was that countries maintained the exchange rate of their currency within a fixed value – a ± 1% band – by intervening in their foreign exchange markets (that is, to buy or sell foreign currency). However, since reserve currency was set to be U.S. dollar while it was the only one with most purchasing power and backed by gold, all foreign currencies were in practice pegged to the dollar and countries bought and sold dollars to keep market exchange rates within agreed bands.

Reason therefore to acquire FER back then was for the countries to meet temporary excess demand for foreign exchange in private markets at the existing exchange rate (Grubel, 1971). FER existed as a liquidity reserve for future imports, short term foreign liabilities and other possible instability in countries' international balances. Foreign exchange reserves were national holdings of gold, convertible foreign exchange and unconditional drawing rights with the International Monetary Fund IMF, which was established in addition to the Bretton Woods system.

Countries were trying to optimize their foreign exchange reserves. The main effects of not holding an adequate amount of FER, according to Grubel, would have been that countries could finance payments disequilibria for shorter periods only. Therefore, they would have been obliged to restore the equilibrium on the double by a more severe and restrictive application of domestic income and price adjustments, exchange rate changes and direct

controls of foreign trade. Thus, smaller aggregate supply of reserves would have meant a lower level of world welfare.

After Bretton Woods collapsed at the beginning of the 1970s', countries to a greater extent let their currencies float, and the world seemed to be marching steadily toward floating exchange rate arrangements (with the exception of Europe of course). In the 21st century, almost one half of all exchange rate regimes used in the world are flexible, or at least that is what governments are officially announcing (Calvo & Reinhart, 2000) and in that sense the motive behind holding FER has to have been altered.

A freely floating exchange rate increases foreign exchange volatility. This may cause problems especially among developing countries, which may lack credibility and strength of financial market. When countries' liabilities are denominated in foreign currencies while assets are in the local currency, unexpected depreciations of the exchange rate deteriorate bank and corporate balance sheets and threaten countries' balance of payments. For this reason, emerging markets seem to suffer from fear of floating (Calvo & Reinhardt, 2000) as they have much smaller variations of the nominal exchange rate, yet facing bigger shocks and interest rate and reserve movements. This is the reason behind freely floating countries' reaction to exchange rate movements by changing monetary policy and intervening in foreign exchange market.

Recent foreign exchange reserve accumulation (starting just before the 21st century) has been far larger and faster than ever witnessed before. Countries especially in Asia (China, Korea, India, Malaysia, Russia and Taiwan) have had the fastest growing reserves among countries as a ratio to GDP. In Latin America and central Europe reserve accumulation has been fairly modest (Mohanty & Turner 2006). Since the rapid growth of foreign exchange reserves especially in China, which by being the largest country draws also the most attention, issue of accumulating FER has resurrected. However, it is now being discussed from a rather negative perspective, and the focus has been on the phenomenon's implications particularly on the international trading partners. Some blame China for keeping its renminbi exchange rate artificially too low to stimulate its exports and

strengthen the current account surplus it has with the United States. Some even have been insinuating the possibility that China is after world supremacy by controlling the economy of the U.S.

Central banks cannot accumulate reserves indefinitely. Excessive reserves entail significant sterilization costs, since the negative spread between the interest earned on reserves and the interest paid on the country's public debt[1] increases with reserve accumulation. Moreover, if capital flows are not sterilized, sustained reserve accumulation will, at some point, generate inflationary pressures that could increase the risk of domestic financial crisis. On the other hand, if these central banks decide to stop accumulating U.S. dollar reserves, they could trigger an abrupt depreciation of the U.S. dollar and a sharp rise in interest rates. Given the potential impact on global interest rates, growth, and financial stability, the issue of Asian reserve accumulation is of considerable importance (Gosselin & Parent, 2005).

What ever is the reason, it would be interesting to at least try to find motives for such (also costly) behaviour. Like Rodrick (2006), also Hauner (2005) examined fiscal effects of holding massive exchange reserves and resulted that after 2004 nearly all country groups in his study were losing money with their reserves, with medians of estimated net costs ranging from -0.4% to 0.8% of GDP[2]. Rodrik pointed out, however, that it might not be that bad of an idea in the end, because of all the positive effects a large reserve can bring.

That is exactly what I'm after with this study. Why emerging economies hold such large reserves? Why the behaviour is clustered today particularly in Asian countries, and have the motives changed for hoarding? What are the positive effects FER bring them? How large are the costs associated with accumulating large foreign exchange reserves, and when are the reserves at their optimal level?

[1] Sterilized intervention discussed more in chapter 2.3
[2] Hauner (2005) more in detail in chapter 5.2.2

1.3 Structure of the thesis

My aim with this study is to address to those questions just posed above. However, I must first go over the phenomenon and its theoretical framework. In the next chapter (chapter 2) I first go over the theory around money, foreign exchange, balance of payments and central bank interventions.

In chapter three I then reveal the immensity of the accumulation of foreign exchange reserves in the world today. After going through how foreign exchange reserves have increased in the world scale, my focus will be in the three economies central to my study, namely South Korea, China and Taiwan and I will broadly go over their contribution to the global FER accumulation. Then, at the end of the third chapter I give the classic responsible explanatory variables as well as the obvious principal reasons behind such behaviour stated already in the recent literature and public debate with my own reflections.

Chapter four is then reserved for empirical analysis. At the beginning I go over some important aspects of monetary policies, exchange rate regimes and functions of national central banks of the three countries essential to my thesis. Rest of the chapter four addresses implications foreign exchange reserves have on domestic economies, domestic policies, and how certain economic indicators have been developing in China, Taiwan and South Korea. I am going through a set of explanatory variables in respect of acquiring large FER and going to study the possible positive effects FER have on the economies by examining countries' foreign exchange rates, inflation development, international trade, credit lending and banking sector in general, investments from and towards abroad as well as government and sovereign debts (short and long term).

I have calculated multiple linear regressions between open economy indicators and foreign exchange reserves for the three countries in question. Through these calculations I try to assess weather these three emerging Asian economies have similar causes for or consequences of (depends a lot of way of thinking) accumulating large foreign exchange reserves. Also it is important to find out whether the need for FER accumulation indeed

comes from financial globalization as is predicted at present, or if reasons for such strategy seem to lie elsewhere and if they have altered during recent years.

In chapter five I first go through different costs of excessive official reserves stated in the recent literature and then go into more details with certain specific theories from working papers published in recent years (Rodrik, 2006; Hauner, 2005; Aizenman & Lee, 2005; Garcia & Soto, 2004). Last of these four papers also provides a model for calculating an optimal level for foreign exchange reserves. I then use the same models used by Hauner (2005) and Garcia & Soto (2004) for the three countries; China, South Korea and Taiwan and see how similar are my results with updated data.

Finally in chapter 6 I draw conclusions and final remarks over the phenomenon of large foreign exchange reserves, condense discussion on costs and benefits, and recapitulate the real economic circumstances in emerging Asia today.

2. Theoretical framework

In this chapter, I will give a somewhat detailed overview around foreign exchange reserves, money supply, exchange rates and foreign trade. First, I must describe the theoretical framework around money market changes and their effects on foreign exchange market. Second, I go over theory around the balance of payments and how foreign exchange reserves affect international trade balances. Finally I define foreign exchange intervention and how it is being sometimes sterilized in order to keep the quantity of money in check in the economy.

2.1 Money and foreign exchange markets

When accumulating foreign exchange reserves, countries are buying foreign exchange with their domestic currency, which naturally increases the supply of domestic currency and thus the quantity of money in the economy. Rise in quantity of money has impacts on country's interest rate as well as on exchange rates. How does it happen then?

I start the consideration by focusing on exchange rate economics (see for ex. Taylor, 1995 and Isard, 1995 pp.74-78). First, markets are considered efficient, that is prices are fully reflecting information which is available to all market participants and it should be impossible for a trader to earn profit by speculating. When also taking in the hypothesis that foreign exchange market participants are endowed with rational expectations and are risk-neutral, we can derive the uncovered interest rate parity condition:

Equation 1: uncovered interest rate parity condition

$$\Delta E^{e}_{t,t-1} = i_t - i^{*}_t$$

Where i refers to domestic interest rate, i^{*} to foreign interest rate and ΔE the change in foreign exchange rate from period t-1 to t, superscript e denoting expectations.

The expected foreign exchange gain from holding one currency rather than another (the expected exchange rate change) must be fully offset by the opportunity cost of holding

funds in this currency rather than the other (the interest rate differential). Empirical studies performed in the 1970's and 1980's draw a conclusion however, that time series for major nominal exchange rates over the recent float were extremely hard to distinguish empirically from pure random walks (Mussa, 1990).

Later, economists have taken into account market participants' expectations as well as some risk premia foreign holdings bring along. If foreign exchange market participants are risk averse, equation 1 may be distorted by the risk premium, because agents demand a higher return than the interest differential in return for the risk of holding foreign currency.

This can be written as:

Equation 2: interest parity condition with risk premium

$$i_t - i_t^* = \Delta E_{t,t-1}^e + \rho_t$$

Where ρ denotes risk premium in time t.

Now the interest rate cost of holding foreign currency (interest rate differential) is equal to expected gain from future depreciation of domestic currency plus a risk premium. An alternative explanation of rejecting simple efficient markets hypothesis is that there is a failure in the expectations component. As examples have been proposed the 'peso problem' (Sill, 2000), learning about regime shifts (Lewis, 1989), and inefficient information processing (Bilson, 1981). Peso problem refers to the situation where agents attach a small probability to a large change in the economic fundamentals, which does not occur in sample. This tends to produce skews in the distribution of forecast errors even if agents' expectations are rational. Similarly, when agents are learning about their environment they may be unable to fully exploit arbitrage opportunities which are apparent in the data *ex-post.*

The peso problem took its name after an episode in which Mexican peso sold at a forward discount for a prolonged period, although it was fixed to U.S. dollar for more than 20 years, prior to its widely anticipated devaluation in 1976 (Sill, 2000). Although market expectations eventually proved correct and may well have been rational *ex ante,* the fact that the devaluation did not materialize immediately after it first became anticipated, made

the forward rate a biased predictor over finite data samples that included the period before devaluation. Even if expectations are formed rationally, within finite data samples the forward exchange rate can be biased as a predictor of future spot rates. More generally, peso problems can arise when the possibility that some infrequent or unprecedented event *may* occur affects asset prices (Sill, 2000).

Although uncovered interest parity is the basic parity condition for assessing the efficiency of foreign exchange market, two other arbitrage conditions which receive considerable attention in the literature are *covered interest rate parity* and *purchasing power parity* (Taylor, 1995 and Isard, 1995 p.76).

Equation 3: Covered interest rate parity

$$\left(i_t - i_t^*\right) - \left(f_t^{(t+1)} - E_t\right) = 0$$

Where $f_t^{(t+1)}$ denotes the forward exchange rate with maturity t+1 and E_t the spot exchange rate.

Arbitrage now ensures that the interest rate differential on similar assets when adjusted for covering in the forward foreign exchange market the movement of currencies at the maturity of underlying assets is continuously equal to zero. Agents cover their investment via the forward market.

Absolute purchasing power parity implies that the exchange rate is equal to the ratio of two relevant national (foreign and domestic) price levels. Relative purchasing power parity states that changes in the exchange rate are equal to changes in relative national prices. That is, foreign exchange rate equalizes the differences among countries' price levels and each country's international competitiveness (their real exchange rates, which I am addressing below) is kept constant over time (Sørensen & Whitta-Jacobsen, 2005, Ch.23).

Equation 4: Purchasing power parity

$$\Delta E_{t,t-1} = \beta p_t + \beta^* p_t^*$$

Where β and β^* are constants and p without and with an asterisk refers to logarithms of domestic and foreign price level respectively.

With constant values $\beta=1$ and $\beta^*= -1$, equation would be interpreted as absolute purchasing power parity, while the same equation (with same constant values) with variables in first differences would stand for relative purchasing power parity (Taylor, 1995). Now, the real exchange rate can be viewed as a measure of the deviation from absolute purchasing power parity:

Equation 5: Real exchange rate, ε

$$\varepsilon = \frac{EP^*}{P}$$

This variable called *real exchange rate* reflects country's international competitiveness, by ratio of the price of foreign goods measured in domestic currency and the price of domestic goods. The bigger the real exchange rate, the cheaper are domestic goods relative to goods produced abroad. The inverse of the real exchange rate, $1/\varepsilon$, is referred to as the international *terms of trade*, since an increase in the real exchange rate implies a deterioration in the terms on which domestic goods can be traded for foreign goods (Sørensen & Whitta-Jacobsen, 2005, p.704).

Measuring real exchange rate in natural logarithms, and looking at the change over two periods, we get: $e^r - e^r_{-1} = \Delta e + \pi^* - \pi$.[3] In the long run when the real exchange rate is constant, we get: $\Delta e = \pi - \pi^*$, that is in the long run country's rate of nominal exchange rate depreciation must correspond to the excess of the domestic over the foreign inflation rate.

Relative purchasing power parity implies that in the long run the domestic real exchange rate is tied to the real interest rate abroad. In the long run, the foreign exchange rate changes are correctly anticipated, so the expected rate of depreciation must equal to the actual rate and we can write equation 1 as $\Delta e_{t+1} = i_t - i_t^*$ and when further combining with equation of the long run relationship derived above, it gives *the real interest rate parity:*

[3] π stands now for inflation

Equation 6: Real interest rate parity

$$i - \pi_{t+1} = i^* - \pi^*_{t+1}$$

While capital mobility establishes a link between the nominal interest rates at home and abroad, the combination of capital mobility and foreign trade also implies a long-run link between domestic and foreign real rates of interest (Sørensen & Whitta-Jacobsen, 2005, p.705).

Albeit having now a somewhat clear picture about exchange rates economics, it is now time to tie them in the context of monetary model in order to see how exchange rates and interest rates are affecting or resulting from the change of monetary volume. I am deriving the monetary equilibria (both nationally and abroad) from a working paper by Mark Taylor written in 1995.

The demand for money is assumed to depend on real income (or alternatively thinking, output) γ, the price level p and the level of nominal interest rate, i. Foreign variables are again denoted by asterisk.

Equation 7: The monetary equilibria

$$m_t = p_t + \kappa\gamma_t - \lambda i_t$$

$$m^*_t = p^*_t + \kappa\gamma^*_t - \lambda i^*_t$$

Where κ and λ are constants and all variables are measured in logarithms.

When now substituting the monetary model into the purchasing power parity condition (equation 4 with constant values $\beta = -\beta^* = 1$), we get equation 8 as follows:

Equation 8: Interdependence between exchange rate and real economy

$$\Delta E_t = m_t - m^*_t - \kappa\left(\gamma_t - \gamma^*_t\right) + \lambda\left(i_t - i^*_t\right)$$

From equation 8 we can see that an increase in the domestic money supply, relative to the foreign money stock, will lead to a rise in exchange rate, so to a depreciation of the domestic currency. A rise in domestic income (or output) will, *ceteris paribus,* create an

excess demand for domestic money stock, which leads exchange rate to decrease and domestic currency to appreciate. Level of the domestic interest rate affects negatively on the demand for money, so when interest rate increases, it reduces domestic money demand and leads domestic currency to depreciate.

The execution of monetary policy requires knowledge about two variables affecting economy's interest rates; namely level of output and inflation. There exists currently a broad consensus that central banks and monetary authorities should aim to reduce inflation and keep it at low levels (Cecchetti & Groshen, 2000).

In addition to understand relations between exchange rates, interest rates and national price levels, I must now also emphasize the impact exchange rates have on international trade and national balance of payments, while it is an important part of my thesis.

2.2 The balance of payments

Country's transactions with the rest of the world (international trade and financial flows) are summarized by a set of accounts called the balance of payments. It includes current account and financial account. In theory, balance of payments is always in equilibrium equalling zero. In reality a country can experience a so called twin-surplus (as China does), which I describe later on.

The current account is the sum of balance of trade, net factor incomes and net transfer payments. First, it includes imports and exports of goods and services (balance of trade). Exports lead to payments from the rest of the world, imports to payments to the rest of the world. Second, residents of a country receive investment income on their holdings of foreign assets, and same goes for foreign residents (net factor income). Also wages paid for foreign residents from one country or income its residents receive from abroad are being recorded in the current account. Finally, countries give and receive foreign aid; net value of these payments is recorded as net transfers received. If net transfers are negative

in some country's current account, it implies that the country is a net donor of foreign aid (Ouanes& Thakur, 1997).

The capital account has four functional categories: First one is direct investment, which is further divided into equity capital, reinvested earnings, and other capital. Direct investment is classified as investments in the economy by residents abroad and by non-residents. Second is portfolio investment, which includes long-term debt and equity securities, money market debt instruments, and tradable financial derivatives including interest rate and currency swaps. Number three are other investments such as trade credits and borrowing (including International Monetary Fund (IMF) credit and loans). Fourth and last are reserve assets that include foreign exchange (currency, deposits, and securities), monetary gold, SDRs[4], and the country's reserve position in the IMF. Despite the name, reserve assets in the standard balance of payments accounts are not stocks but changes in gross external assets. Reserve assets are under direct control of the monetary authorities and can be used either *directly* to finance payment imbalances, or *indirectly* to regulate imbalances by, for instance, intervening in foreign exchange markets to support the value of the currency. (Ouanes & Thakur, 1997, p.100-101). Reserve asset flows exclude those that are not attributable to transactions.

How balance of payments is associated with exchange rates? I am studying effects through a Mundell-Fleming model, which portrays relationship between nominal exchange rate and output in a small open economy, as used in Asada et al. (2003). Model is an elaboration of the traditional IS-LM model representing equilibria in goods and money markets under autarky. Although Mundell-Fleming model seems somewhat incomplete and unbalanced (Asada et al., 2003) it still provides the basic interdependence of exchange rate dynamics in trade balance. The model consists of the following three equations representing goods-market equilibrium (IS), money-market equilibrium (LM) and the imbalance in the market for foreign exchange (Z):

[4] SDR = Special Drawing Rights. A form of international reserve assets created by IMF in 1967, whose value is based on a portfolio of widely used currencies

Equation 9: IS-LM-Z model

$$Y = C\left(Y - \overline{T}\right) + I(i) + \overline{G} + NX\left(Y, \overline{Y}^*, e\right)$$

$$M = m^d\left(Y, i\right)$$

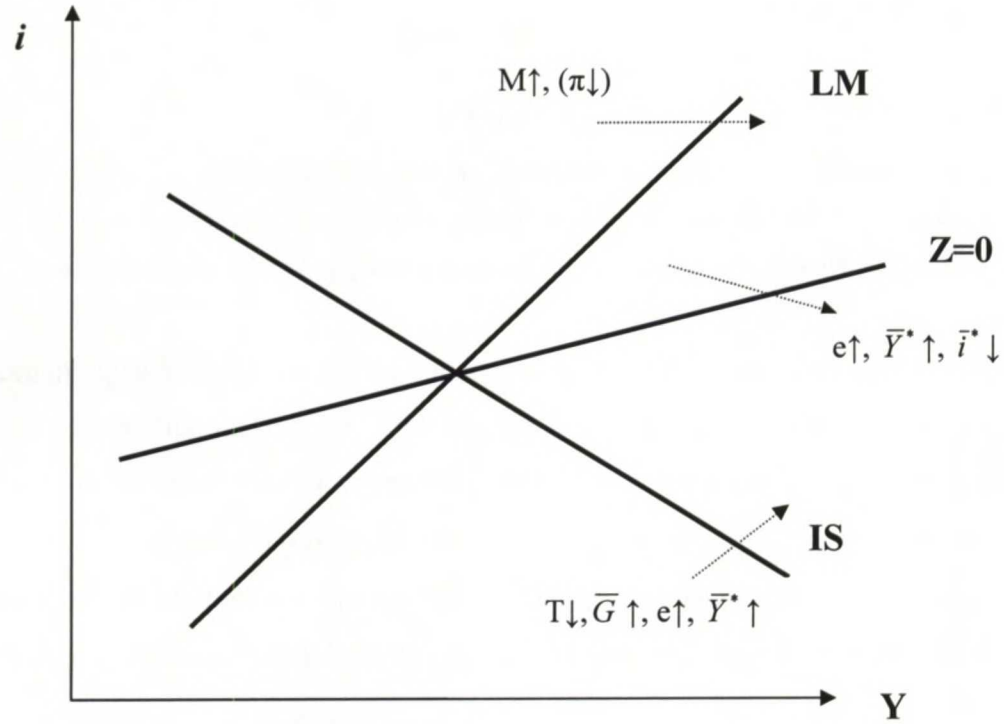
$$Z = NX\left(Y, \overline{Y}^*, e\right) + NXB\left(i, \overline{i}^*\right) = NX\left(Y, \overline{Y}^*, e\right) + NK\left(i, \overline{i}^*\right)$$

Where i is the nominal interest rate, I denotes investments, G government spending, C consumption, NX net commodity exports and NXB (or NK) denotes net bond exports (or net capital imports=liquidity). NX and NXB (NK) are measured in domestic currency units. Bars denote that foreign variables are taken as given.

Equation Z describes excess supply of foreign exchange on the foreign exchange market (measured in domestic currency) which is given by the sum of net commodity exports and net capital imports. Net capital imports are assumed to depend positively on the domestic rate of interest i and negatively on the given foreign rate of interest $\overline{i}^*$. Current and capital account are determined independently and the size of current account surplus depends positively on the real exchange rate and negatively on real income while prices are considered to be fixed.

In the next figure IS-, LM- and Z-curves are drawn in interest rate-output framework with comparative statics. There exists excess supply of foreign currency on the foreign exchange market for situations above the Z = 0 curve (balance of payments amends) and excess demand below it (balance of payments deteriorates).

Figure 1: IS-LM-Z framework



Source: Asada et al., 2003 p.128-130

When for example central bank generates a monetary expansion, that is, increases the supply of money, LM curve shifts to the right and interest rate falls. Output expands and income increases which moves IS-curve upwards. When domestic interest rates are lower than abroad, it decreases demand for domestic currency and increases demand for foreign currency, i.e. we are below the Z = 0-curve. Due to capital outflows, country's balance of payment deteriorates. In order to get all three markets back in equilibrium exchange rate must increase pushing domestic currency to depreciate and Z = 0-curve will shift downwards to meet the new equilibrium point, improving the balance of payments .

All in all, like I already stated, a country's balance of payments always equals zero (at least in theory), because if a country is running a current account deficit (for instance importing much more than it exports), it must finance it through an equally positive net capital flows. As with China, the situation is different. China is currently running a twin-surplus (Yu, 2005) that is a surplus in its current account as well as in its capital account

(its balance of payment is positive). Inexpensive renminbi is boosting Chinese exports which lead to a large current account surplus. Simultaneously with the money piling from export payments and high domestic savings rate, China is receiving large foreign investments and while further practicing at least somewhat expansionary monetary policy, country's monetary authorities have been able to accumulate also huge capital account surplus. With time, renminbi appreciation would push the Z = 0 –curve upwards to bring markets back to balance.

A current account deficit does not necessarily call for policy adjustment, since a deficit may be a temporary imbalance caused by a drop in export prices. But a current account deficit that has persisted necessitates policy adjustments since a country can not continue to finance deficits indefinitely by borrowing abroad or running down international reserves (Vos et al., 2008). In the case of freely floating exchange rates, when demand for domestic goods increase, it increases simultaneously the demand for domestic currency, since foreigners need to have domestic currency to pay for their imports. While the demand for say, Chinese products, increase it increases also the demand for RMB[5], and thus the nominal exchange rate (in the case of free floating) should decrease, indicating the appreciation of renminbi. The imbalance in trade would then automatically be erased through corrective measures of exchange rates (as described with IS-LM-Z model).

Nonetheless, sometimes the central bank desires, or is pressured, to take actions to either raise or lower the exchange rate in a floating exchange rate system. First reason why central bank intervenes is trying to stabilize fluctuations in the exchange market. International trade and investment decisions are harder to make if the exchange rate value changes rapidly. Another reason is to reverse the growth in the domestic trade deficit. Appreciating currency causes trade deficit to grow as already seen, and if that trade deficit is seen as a problem for domestic economy, central bank can try to reverse its direction by intervening and reducing the value of domestic currency in the foreign exchange market. What can the central banks do then about exchange rates and how can they alter them

[5] RMB = Renminbi, Chinese domestic currency

when necessary? Let's turn next to the foreign exchange intervention and its consequences.

2.3 Monetary policy and foreign exchange intervention

World economy operated under a system of Bretton Woods (somewhat fixed dollar exchange rates) between the end of WWII and 1973, with central banks routinely trading foreign exchange with dollars to hold their exchange rates at internationally agreed levels. Today also countries, which (at least claim to) have let their currency float freely, are conducting foreign exchange interventions, the main reason behind not necessarily being to affect exchange rate formation but to accumulate country's foreign exchange reserves for some other reason(s).

Main tool in explaining foreign exchange intervention is the central bank balance sheet, which records central bank's assets and liabilities. Like any other balance sheet, it is organized according to the principals of double-entry bookkeeping. Below is shown the structure of the balance sheet in question (Sarno & Taylor, 2001).

Table 1: Monetary authority balance sheet

Assets	**Liabilities**
Net Foreign Assets (NFA) o foreign currency O gold	Monetary base (M) o total currency in circulation O reserve liabilities to commercial banks
Net Domestic Assets (NDA) o government securities o loans on commercial banks O other	Net Worth (NW) o spending surpluses O net interests and capital gains from assets

Source: Sarno & Taylor, 2001

Above is a stylized representation of the balance sheet of a country's monetary authorities (central bank and exchange-stabilization authorities combined). Monetary base comprises of total currency in circulation and deposit liabilities to banks. Net worth of the financial

authorities includes accrued spending surpluses, accumulated net interest receipts and capital gains on their holdings of net domestic and foreign assets (Sarno & Taylor, 2001).

From table 1 it follows that:

Equation 10: Monetary authority's balance sheet

$$M \equiv NFA + (NDA - NW) \equiv NFA + DC$$

Where DC, defined as net domestic assets minus net worth, represent the stock of domestic credit made available by the monetary authority.

Central bank has two methods to intervene in the foreign exchange market resulting in exchange rate alteration. The first one is called *indirect foreign exchange intervention*, where the central bank raises or lowers exchange rate through changing the domestic money supply. This effect may take several weeks, however to function and in order to make the public want to hold more money, central bank has to lower the domestic interest rate. Thus, to change the exchange rate using indirect method, central bank may need to change interest rates away from what it views as appropriate for domestic concerns at the moment.

The second method is called *direct foreign exchange intervention*, where central bank affects real economy through entering straight the foreign exchange market by buying or selling foreign exchange. As an example, let's say the Bank of Korea (BOK) buys U.S. dollars to acquire Treasury bills with national currency (wons). This transaction will raise the supply of wons and also raise the demand for dollars, causing a reduction in the value of won and thus a won depreciation. Of course, when won depreciates in value, dollar appreciates in value with respect to the won.

When official intervention is non-sterilized, looking at central bank balance sheet (Table 1) there is now an increase in NFA and an equivalent increase in M. That is, supply of wons increases due to the transaction. When central bank intervenes in the foreign exchange market, a purchase of foreign currency financed by selling domestic currency leads to an equal increase in its international reserves and the monetary base.

As I already stated previously in chapter 2.1, monetary expansion or an increase in money supply leads in the short run to a depreciation of domestic currency and a decrease in interest rates. These have large effects on the whole. Expansion of monetary base can be nullified through *sterilized intervention*. If in our example Bank of Korea wishes to keep the domestic monetary base unchanged, it can issue won based government bonds, and by selling them it collects the excess money back from the market. As a result, foreign exchange intervention and the offsetting open market operation leave the monetary base unchanged only altering domestic credit.

Equation 11: Effects of sterilized intervention

$$\Delta DC = -NFA \Rightarrow$$
$$\Delta M = \Delta NFA + \Delta DC = 0 \Rightarrow$$
$$\Delta NDA = -\Delta NFA$$

By the strict and fairly simple model, sterilization being fully offsetting, accumulation of foreign exchange reserves would not affect interest rates or exchange rate of domestic currency. However, official purchases and sales of foreign exchange, being sterilized afterwards or not, directly affect the flow demands and flow supplies of foreign exchange that must be balanced in determining the current exchange rate (Mussa, 1981).

Some more recent studies state however, that sterilized intervention would have also other short run and long run effects on the exchange rates (see for ex. Fatum & Hutchison, 2003, 2003, Sarno & Taylor, 2001 and Hutchison, 2003). Fatum and Hutchison used daily data and looked at intervention episodes – periods of several days running when intervention is intense and persistent – and link intervention with systematic exchange rate changes. They found that intervention operations are usually successful in either slowing or reversing the direction of exchange rate change over periods of up to two weeks.

And while central bank is able to affect foreign exchange rates, simultaneously erasing the inflationary effect of monetary base increase by sterilizing, it can now influence the real exchange rate (equation 5) and thus affect trade balance and capital flows (Green & Torgerson, 2007). Next I am addressing few theoretical explanations on how sterilized

interventions could affect the exchange rate; portfolio balance channel, expectations or signalling channel (see Mussa, 1981) and coordination channel (Sarno & Taylor, 2001).

The *portfolio balance channel* works through the framework of a portfolio balance model of exchange rate determination in which investors balance their portfolio among the assets of various countries on the basis of their relative expected returns. When monetary authority has conducted a sterilized intervention, the monetary base has not altered. However, the composition of agents' portfolios has indeed been changed, since authorities will have bought or sold domestic bonds in their sterilisation operations. The spot exchange rate must therefore shift in order to affect the domestic value of foreign bonds and the expected return for holding them (Sarno & Taylor, 2001). For example an increase in the supply of won-denominated bonds in the hands of the public relative to the supply of dollar-denominated assets necessitates a fall in the relative price of won-denominated bonds, and domestic currency depreciates in South Korea. This is how, in theory, sterilized (or pure) intervention affects the exchange rate through portfolio balance channel.

The signalling channel is based on theory that agents in foreign exchange market may view exchange rate intervention as a signal about future stance of monetary policy (Mussa, 1981). Exchange rates being a forward looking variable, expectations play a big role in determining the spot rate. Monetary authorities are providing market new relevant information by committing pure intervention and if investors are being made to change their expectations and beliefs about the future, a more long lasting effect can occur in exchange rates.

One way to manipulate agents' beliefs and expectations would be that a central bank intervening foreign exchange market would announce it, but not the fact that it is at the same time in fact sterilizing and offsetting the increase in monetary base. Getting information about the sterilization would require the investors to carefully examine different markets, which takes as well time as it takes money. In this way investors may be fooled to anticipate domestic currency depreciation in the future, and expectations would then move also to present value. However, when agents eventually notice *ex-post* that

sterilization did in fact happen, central bank may well lose its credibility when later trying to announce any further official interventions.

The third possible channel of influence is called, according to Sarno and Taylor, *the coordination channel*, which they state, has gained very little attention in the literature. Namely, official intervention has a corrective role in coordination failures in the foreign exchange market. Putting it in an example, the foreign exchange market may be subject to many irrational speculative bubbles brought about by important non-economic factors such as chartist or technical analysis which are known to have a significant effect on the market and which may impart swift movements of the exchange rate away from the level consistent with underlying economic fundamentals. Once the exchange rate has moved a long way away from that level, it may be very hard for individual agents to bring the exchange rate back, even though they may strongly believe it to be misaligned, because of a coordination failure. If all the traders with that believe would simultaneously act upon and sell the currency which they see overvalued, the bubble would burst. Publicly announced intervention operations could be seen as fulfilling a coordinating role in that they would gather together the 'smart money' to enter the market at the same time.

It is however crucial to notice, that central banks ability to intervene depends on the direction of the transaction. If the central bank wishes to reduce the value of domestic currency (by buying foreign exchange with domestic currency and thus increasing the domestic money supply) it can do so indefinitely. Why? Because central bank is the ultimate source of domestic currency and so it can flood the foreign exchange market with as much domestic currency as they desire. On the other hand, in order to have the reverse impact in the foreign exchange rate, that is to increase the value of domestic currency, the central bank has to buy domestic currency (to decrease its supply) by selling foreign exchange. To be able to do so, it must have large enough foreign exchange reserves. In the next chapter I am indeed going to see how large foreign exchange reserves countries have at present.

3. Overview of the Phenomenon

In this third chapter I am first going through the vast phenomenon of foreign exchange accumulation in the world today through statistics and data. I also address some aspects related to the accumulation; the fact that central banks around the world (especially in developing countries) are worried about the dollar foreign exchange rate development and are shifting their FER away from dollar-denominated bonds, and the criticism foreign exchange reserve accumulation has attained mainly from Europeans and Americans.

Second, empirical work has already identified a relatively stable long-run demand for reserves that is based on a limited set of explanatory variables, which I list in chapter 3.2.1. I then go through more specifically some of the most common reasons for large FER accumulation presented by recent literature and press and my own reflections on them, namely because countries are: preparing for time of crises, trying to find use for increased savings, able to drawn cheaper loan, and in order to tamper the exchange rates.

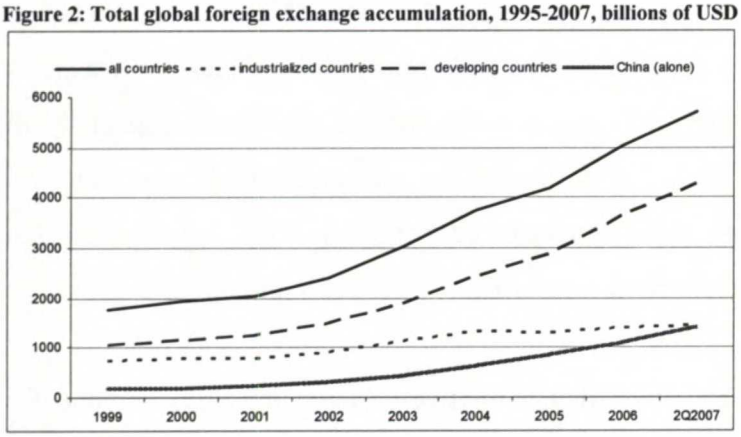
3.1 The immensity of FER today

Recently, during the 21st century, markets in transition in Asia, Latin America and formal Soviet Union have been collecting massive foreign exchange reserves, mostly in dollars, on an unprecedented scale. As a ratio to GDP, such ratio has been particularly rapid in China, Korea, India, Malaysia, Russia and Taiwan (Mohanty & Turner 2006). Between 2000 and 2006, emerging market economies accumulated reserves at an annual average pace of $415 billion, or year-to-year rate of 35.9%. Same figures for industrialized economies are $102 billion and 13% respectively.

Total global foreign exchange reserves did in fact reach 6000 billion dollars by the end of 2007. In the next figure, I show the accumulation of official foreign exchange reserves

starting from 1999, in the world as a whole and for both industrialized and developing countries separately[6].

Figure 2: Total global foreign exchange accumulation, 1995-2007, billions of USD



Source: IMF

As can be seen from the figure above the accumulation that has occurred in the world in the 21st century is almost entirely due to developing countries and markets in transition. Albeit the amount of foreign exchange reserves has also been increasing among industrialized countries, the accumulation is fairly stable and has grown just less than twofold. Among developing countries, the size of FER is more than four times as high it was only eight years ago. China alone had in second quarter of 2007 official reserves equal all industrialized economies' official reserves combined and one fourth of world's total reserves.

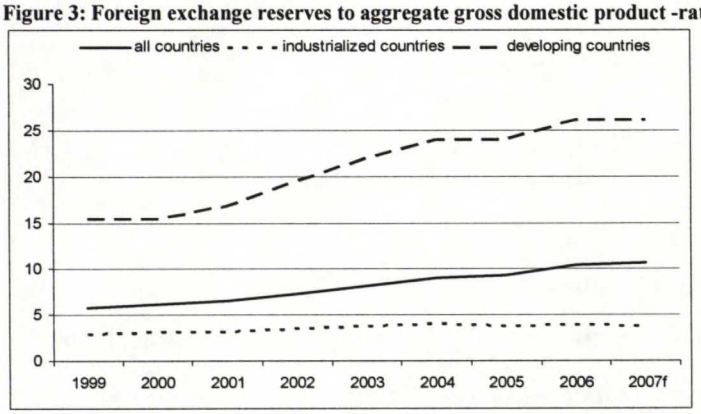
One aspect related to the stabilization of foreign exchange reserves in industrialized countries is the fact that when European states unified and adopted common currency, they have been able to economize on the use of foreign exchange while all transactions between countries within the euro area are now domestic transactions. They thus require foreign currency only to purchase goods and services or to make investments outside the euro area. According to BIS statistics (2007), already at the end of 2004 France held 75% of the foreign exchange reserves it held before entering the euro, Germany 62%, Greece

[6] Industrialized countries include: Australia, Austria, Belgium, Canada, Cyprus, Denmark, Finland, Germany, Greece, Ireland, Iceland, Italy, Japan, Luxemburg, Netherlands, New Zealand, Norway, Portugal, Slovenia, Spain, Sweden, Switzerland, UK, and U.S.
Developing countries include 160 countries in Asia (including Taiwan, Korea and China), Africa, Middle-East, Eastern Europe, and Latin America. (IMF)

22%, Belgium 52%, Netherlands 45% and Spain 21.5%. Using a simple average, euro countries held in 2004 about 40% on reserves of what they held in 1998.

After the second quarter of 2007, industrialized countries' foreign exchange reserves were 1,443 billion dollars and for developing countries 4,269 billion dollars. In proportion to GDP, which is forecasted to attain 38,696 billion dollars for industrialized and 14,655 billion dollars for developing countries in 2007, percentages are 3.7% and 26.1% respectively. In the figure below I have gathered statistics from IMF on foreign exchange reserves to gross domestic product –ratio from the world as whole as well as from industrialized and developing economies separately.

Figure 3: Foreign exchange reserves to aggregate gross domestic product -ratio, 1999 – 2007f, %



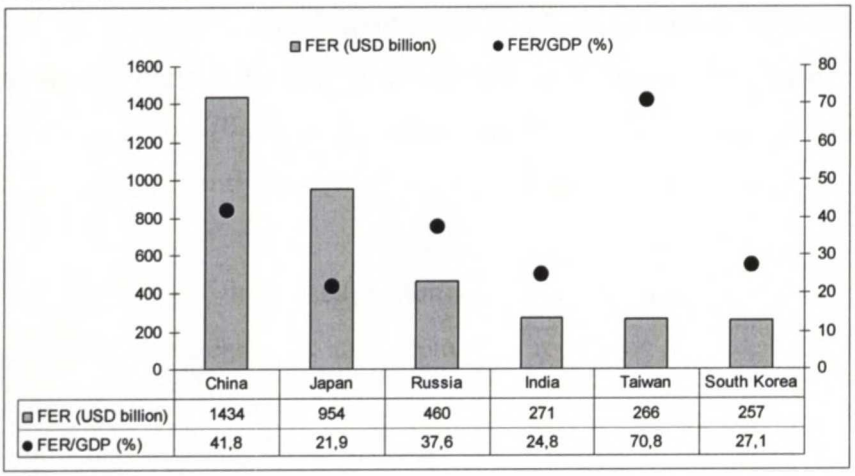
Source: IMF, f = forecast

As can be seen, the FER/GDP ratio is today much greater among developing economies than industrialized ones. Although the order has stayed the same for a long time, the ratios have grown further apart. Before the 21st century foreign exchange reserves were 15.5% of gross domestic product among developing countries while it was only 2.9% and 5.7% for industrialized economies and for all countries respectively.

In 2007 (IMF forecast) the difference is clearly bigger. The FER/GDP ratio is already 26.1% for developing economies. That means their aggregate foreign exchange reserves are worth more than one fourth of their aggregate annual GDP. As for industrialized countries, the ratio has increased with less than one percentage point to 3.7%.

Setting the world as whole aside, let's turn to the countries that have the largest official foreign exchange reserves in the world. IMF classification earlier showed accurately the immensity of foreign exchange reserves in the world today and the fact that it is mostly piled up in economies trying to catch up.

Figure 4: Monetary authorities with the largest foreign exchange reserves in 3Q 2007 billion USD and FER/GDP - ratio[7]



	China	Japan	Russia	India	Taiwan	South Korea
FER (USD billion)	1434	954	460	271	266	257
FER/GDP (%)	41,8	21,9	37,6	24,8	70,8	27,1

Source: IMF

As can be seen from figure 4, in the third quarter of 2007 China holds by far the largest amount of foreign exchange reserves in the world. Chinese FER surpasses Japan's equivalent by nearly 500 billion dollars. Albeit China is far ahead in absolute terms, the foreign exchange reserves accumulated especially by Taiwan are outstanding when compared to country's GDP. Ratio of foreign exchange reserves per gross domestic product is over 70 % for Taiwan, while in Japan it has steadily decreased for some time now and is currently below 22%.

With countries' increased accumulation of foreign exchange reserves and growing international integration, considerations regarding reserve adequacy have been shifting from an emphasis on countries openness (usually associated with the 'three-months of imports' rule) towards financial account and balance sheet fragilities (associated with the

[7] GDP – data from IMF estimates (World Economic Outlook Database 2007)

'Greenspan-Guidotti' rule[8], according to which a country should have foreign exchange reserves covering its short-term debt (≤ 1 year of maturity), see for ex. Greenspan, 1999 and Green & Torgerson, 2007). Based on BIS 77th Annual Report 2007, the measures of adequacy for foreign exchange reserves for the world today are as follows:

Table 2: FER and measures of adequacy

	Reserves Outstanding (billion USD)		Reserves/ Imports (months of imports)		Reserves/ Broad money (%)		Reserves/ Short-term debt[1]	
	2000	2006	2000	2006	2000	2006	2000	2006
China	166	1066	9	16	10	24	8	13
Japan	347	875	11	18	6	15	2	2
Taiwan	107	266	9	16	19	34	8	8
Russia	24	295	6	20	44	77	2	5
Korea	96	238	7	9	29	38	2	2
Other Asia[2]	325	647	6	7	27	30	2	2
Latin America[3]	136	271	5	7	23	25	1	2
Middle East[4]	75	178	9	8	25	30	2	2
Central and eastern Europe[5]	69	181	5	4	39	36	2	1
Industrial Economies[6]	344	334	1	1	3	2	0	0

[1] Short-term external debt defined as consolidated international claims of all BIS reporting banks on countries outside the reporting area with a maturity up to and including one year plus international debt securities outstanding with maturity up to one year. For Libya and Saudi-Arabia, excludes international securities. [2] Honk Kong, India, Indonesia, Malaysia, the Philippines, Singapore and Thailand. [3] Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela. [4] Egypt, Jordan, Kuwait, Lebanon, Libya, Oman, Qatar, Saudi Arabia and the United Arab Emirates. [5] Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia. [6] Canada, euro area, Switzerland, the UK and the U.S.

Source: BIS 77th Annual Report

As can be noted from the table above, measured by the three most used measures of adequacy, the magnitude of foreign exchange reserves of certain countries is immensely bigger than for example that of the industrial economies or even the oil-exporting countries of the Middle East[9].

The most common factor considered in judging reserve adequacy is the equivalent number of months of imports. Idea behind the figure is that it tells how long a country could continue to import if all other inflows of foreign exchange would dried up. For many years

[8] Named after Pablo Guidotti, a former Argentine finance officer and Alan Greenspan, the former American Federal Reserve chairman who called for developing countries to amass enough foreign exchange reserves to cover all their foreign debt coming due within the next year.

[9] Widespread opinion has been that these oil-exporting countries should have larger FER because of the risk involved in volatility of raw-material world prices and countries' great dependence on international trade.

the adequate number of months of imports was three, being accepted also by the International Monetary Fund. However, in recent years particularly after the South East Asian crisis this has been questioned. Import-based measures can be especially useful for low-income countries without significant access to capital markets and vulnerable to capital account shocks, such as a fall in the price of country's main export or a drop in tourism receipts due to natural disaster (Green & Torgerson, 2007). While countries become more and more dependent on international trade, their vulnerability towards trade imbalances increase, and three months worth of imports may well be too short-sighted.

Amongst industrialized countries the reserves per imports ratio was both for years 2000 and 2006 only 1 month of imports. For China, the number of months their reserves would cover rose from 9 in 2000 to 16 in 2006. The rise was high as well for Japan, Russia and Taiwan. In other words, even if all money flows would dry up, the Chinese could still continue to import goods and services for almost a year and a half at current pace from abroad.

Debt based indicators have as well been developed as means of measuring reserve adequacy. Measure used in table 2 is the level of reserves to short term debt by remaining maturity. The initial rule of thumb named the Greenspan-Guidotti rule (see above) obliged countries to cover their short term debt with their international reserves, which became the most widely used benchmark for measuring vulnerability to capital account crises (Green & Torgerson, 2007). Currently in China, foreign exchange reserves would cover short term debt thirteen-fold. The figure has grown from eight in 2000 to thirteen in just six years. In Taiwan FER are eight times larger than short term debt. Only in Japan and Korea the ratio is the size of two.

One measure of liquidity is the size of broad money and the ratio between it and FER. Countries facing a risk of capital flight may follow money-based measures, as reserve balances held against a portion of the monetary base can increase confidence in local currency (Green & Torgerson, 2007). While a conventional minimum adequate level of reserves is lacking, Wijnholds and Kapteyn (2001) suggested that reserves equivalent to 5-

20% of broad money, depending on the exchange rate, as an appropriate buffer. Wijnholds and Kapteyn state that the risk that domestic residents will wish to convert local into foreign liquidity will be greater for countries with a currency peg than for countries with a more flexible exchange rate.

In Central and Eastern Europe as well as with industrialized countries the ratio has declined, while with all other countries and country-groups in table 2 the exact opposite has occurred. With South Korea and Taiwan, the buffer band suggested above is well exceeded, being 38% and 34% respectively. Russia is holding the largest reserve in terms of broad money, percentage being 77%. When the amount of foreign reserves is being accumulated faster than supply of broad money, it also means that at least some of foreign exchange accumulation is being sterilized, i.e. all accumulation has not been affecting monetary base. In all of the three cases, ratio has increased fairly quickly; for China, South Korea and Taiwan 14, 9 and 15 percentage points respectively in 6 years.

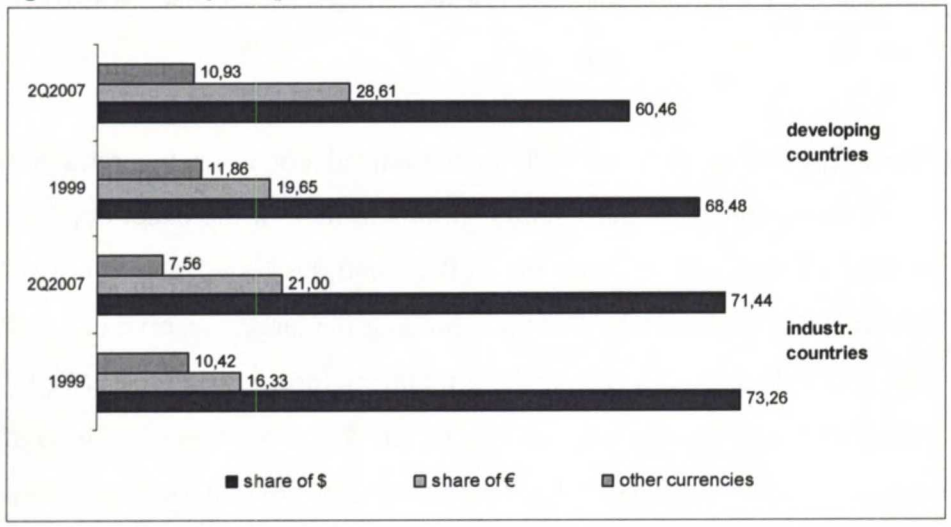
3.1.1 U.S. dollar losing its lead

FER accumulation at a fast pace is not entirely without problems. Developed countries have begun to argue that the counterpart to the Asian countries' current account surpluses and acquisition of dollar reserves – which is the large current account deficit in the United States – could, in due course, cause investors to start worry about the US's ability to repay (Williams, 2005). This, it is suggested, could then contribute to potential instability of the international financial system. However, the international system is already taking corrective measures. Data show that the share of US dollars in the official holding of global FER has declined, and mostly reflected in a shift to the euro (as can be seen from figure 5).

The share of dollar as the ruling currency in foreign exchange reserves is fading more visibly among the developing countries than industrialized ones. In figure 5 below I have drawn the development of currency composition of foreign exchange reserves for

developing and industrialized countries separately comparing situations of 1999 and second quarter of 2007.

Figure 5: Currency composition of FER in the world in 1999 and 2Q2007[10]



Source: IMF

Dollar is losing its value as the most important foreign exchange reserve currency, especially among developing countries. It probably is due to the fact of the large, excessive and costly reserves developing countries are holding whose profitability is decreasing at the same pace as the dollar has been losing its value already for some years now. Industrial countries are still heavily depending on dollar denominated investments with their foreign exchange reserves, while nearly 72% of all their reserves were dollars. With developing countries however, the share of dollars has declined from 68.5% in 1999 to 60.5% in just seven years, while euros count currently nearly one third of aggregate reserves (28.6%).

By the end of 2006, central banks around the world were already talking publicly about diversifying their allocations of foreign reserves away from dollar-denominated assets and government bonds. For example in October 2006, Russia's central bank said it considers to add more Japanese yen to its reserves, and in December same year the central bank of United Arab Emirates said it would consider putting more of its reserves into euros. (Herald Tribune Business, 2007). Interest in Japanese Yen was understandable in 2006 because of the rise in interest rates. According to ECONSTAT, Japan's 10 year

[10] 2Q2007 refers to data from second quarter of 2007, so the situation after the first six months

Government Bond yield value in 2006 rose from 1.649% to 3.52%, however it declined again the next year.

There are several particular things when considering central bank's portfolio diversification (EMM, 2007). For one, central banks will want to invest their excess reserves in liquid currencies, thereby precluding minor units, even though the latter's yields may be high and it would make sense to diversify. They also would require their diversification destinations to be rated at least A, and in all reserves should align broadly with country's trade pattern. Also the host country's attitude can cause problems. If an economy is regarded as reluctant to allow its currency to become subject to external interest, it will deter potential buyers. With euro currently so strong, European Central Bank is surely reluctant to see Asian central banks snap up billions of euros.

A panel discussion at the Euromoney 7th Annual Forex Forum in London on May 2-3, 2007 (EMM, 2007) suggested that Australian, Canadian and New Zealand dollars as well as Norwegian and Swedish crowns stand to gain interest. The yen should also see renewed interest after slipped behind the pound sterling in recent years as a global currency, although one panelist said that Japan Government Bond yields would have to rise to 2.50-3.00% before they attracted serious demand (currently the 10-year yield is only around 1.5%).

3.1.2 Criticism towards FER

At the end of November 2007 European Union sent a delegation of its most important economic figures in China to put pressure on Beijing on the long-term currency-dispute. As a thin result, the European Central Bank and People's Bank of China decided to establish a working group to revise more about currency matters. "The trade deficit is at unsustainable levels right now and this required a political response", said José Sócrates, prime minister of Portugal, which hold the rotating EU presidency (Financial Times, 2007)

European Union is criticizing renminbi being undervalued in terms of euros, and thus contributing unfairly towards Chinese exports. Trade balance between China and thirteen euro-countries is running a deficit of 70 billion Euros, increasing 25% between January and August 2007 (BBC, 2007). China's exports are way over European imports. Between June 2005 and summer 2007, renminbi has depreciated against the euro almost 10%, while the exact opposite happened against U.S. Dollar. Chairman of the EU- delegation, Jean-Claude Juncker already warned that if not altered, the situation might cause protectionism to strengthen in Europe.

In fact, this effect on international trade balances is apparently the one raising negative comments against foreign exchange reserves. Quite understandably though, taking into account that the openness of world trade today is huge, countries are largely dependent on their exports and governments do not like trade deficits. A country that consistently has its imports exceeding exports accumulates debt vis-à-vis the rest of the world, and therefore has to pay steadily higher interest payments for its debt.

In United States, the current account deficit has been growing since the end of the 1990s' and is currently already 812 billion dollars, or 6.2% of GDP (year 2006). China's contribution in this deficit is 233 billion dollars, or 29%. The reason for America's large trade deficit comes from the nature of their domestic economy (Elwell, 2007). The two main causes are the very high U.S. growth rate during the second half of the 1990s' relative to the growth rate of its main trading partners and the steady real appreciation of the U.S. dollar before 2001. Strong growth rate, while boosted by domestic demand, increased imports more than the exports grew - taken the fact that growth of the trading partners was not as high. Still today the consumption is extremely high in the United States and domestic savings can not keep up. That is why U.S. households are financing their consumption by borrowing from abroad.

Normally the real depreciation of the U.S. dollar should make the trade imbalance disappear, but while transition economies are strongly increasing dollar demand by accumulating foreign exchange reserves, dollar can not depreciate as much as it otherwise

would. This is why opponents are blaming especially China for keeping renminbi artificially too low relative to the dollar to enhance exports further.

While the revaluation of the renminbi was originally (and should be treated as) an economic problem, it has been evolved into a political issue especially within the United States. U.S. government already in the early 2003 made the Financial Department investigate whether the practice of the Chinese artificially forcing down the exchange rate of the renminbi has generated domestic real economy problems in the United States, such as impacts on the employment market. It seems however, that the more U.S. government officials blame Chinese for tampering with exchange rates, the more China will keep up with its strategy. Even Japan has supported the view of the Americans and publicly announced the need for a renminbi appreciation.

Japan however remembers well the events its own economy went through after external powers forcing yen to appreciate in 1985 by the *Plaza Agreement*[11]. The exchange rate value of the dollar versus the yen declined more than 80% over the few following years (Funke & Gronwald, 2008). Currency speculations caused the yen to continue its rise after the end of the coordinated interventions and it appreciated altogether two-fold in the next ten years (McKinnon and Schnabl, 2003). Reason for the Japanese to allow their currency to appreciate was the pressure they felt from the United States, which tried to find a solution to its growing current account deficit and arising emergence of serious recession that began in the early 1980s'. The recessionary effects of the strengthened yen in Japan's export-dependent economy created an incentive for expansionary monetary policies that led to the Japanese asset price bubble of the late 1980s', probably one of the most famous economic bubbles of modern economies. Japan's own experience taken into account makes the pressure China is experiencing even more curious. It could not be in anyone's interest to shake up China's economic growth, especially now when the ones in the United States and even Europe seem to be ceasing. With the huge FER China is holding,

[11] Plaza Agreement or Plaza Accord was an agreement signed on September 22, 1985 at the Plaza Hotel in New York City by 5 nations (France, West Germany, Japan, the United States and the United Kingdom). The five agreed, amongst others, to depreciate the U.S. dollar in relation to the Japanese yen and German mark by intervening in currency markets.

pressuring the country to appreciate its currency from outside is substantially harder than with Japan two decades ago.

What could the Asian countries having accumulated huge foreign exchange reserves do then about the situation according to observers; every option is somewhat bad and unattractive (Yu, 2005). Because of the huge American current account deficits, U.S. dollar has started its long expected descending which is necessary to correct global trade imbalances. As a result, the wobbly dollar causes trouble for those economies that have accumulated huge amounts of U.S. Treasury bonds. If those central banks do nothing and simply hold on to the dollars, the losses will increase when U.S. dollar continues to devaluate. On the other hand, if they buy more dollars to prop it up, they will eventually only have a bigger version of the same problem. Then again, if they swap to other currencies, they will drive the dollar down faster and create a bigger problem and greater losses. The dilemma is troubling.

3.2 Reasons behind the accumulation

The phenomenon is recent as I have already stated, and the reasons behind it are somewhat complex and ambiguous. In this chapter I'm going through some whys and wherefores stated in lately literature as well as my own conclusions on matters. First, however I list the classic explanatory variables identified in recent studies for a long-run demand for foreign reserves.

3.2.1 Classic explanatory variables associated with FER accumulation

The main reason why countries are holding foreign exchange reserves is to smooth unpredictable and temporary imbalances in international payments. Thus, the basic idea in the theory is that a country chooses a level of reserves to balance the macroeconomic

adjustment costs incurred if reserves are exhausted with the opportunity cost of holding reserves. Building on this theory empirical work has identified a relatively stable long-run demand for reserves that is based on a limited set of explanatory variables (IMF, 2003; Lane & Burke, 2001; Gosselin & Parent, 2005). There are five key factors in explaining why countries' see they need to accumulate FER:

1) *Economic size.* Affects positively accumulation of foreign exchange reserves. To the extent that international transactions increase with economic size, reserves are expected to rise with population and real GDP per capita.
2) *Current account vulnerability.* Affects also positively; a more open economy is more vulnerable to external shocks, so greater trade openness leads to higher reserve holdings. Also, larger external shocks (say, export volatility) are associated with higher level of reserves. Explanatory variables being the share of imports or exports (or both) in output, and volatility of exports (standard deviations).
3) *Capital account vulnerability.* As with the previous variable, greater financial openness could be associated with higher crises vulnerability and thus influence the demand for reserves. Also, the greater the possibility for resident-based capital flight from the domestic currency, the higher the level of reserves. As explanatory variables, ratio of capital flows or M2 to GDP, short-term external debt, and foreigners' equity position are being used.
4) *Exchange rate flexibility.* Has a reverse effect on level of reserves. Greater flexibility reduces the demand for reserves, because monetary authorities no longer need a large stockpile of reserves to manage a pegged exchange rate. Explanatory variable of exchange rate flexibility can be the volatility of exchange rate.
5) *Opportunity cost.* The opportunity cost is the difference between the yield on reserves and the marginal productivity of an alternative investment, so the interest rate differentials. The greater the opportunity cost, the lower the level of reserves.

In IMF calculations (IMF, 2003) the simple correlations between reserves and each of the explanatory variables are consistent with the theoretical predictions. However, sample consisted of emerging Asian countries between 1980 and 1996, and as soon as predictions

of the model were applied for the following years, from 1997 to 2002, differences began to show. After year 2000, the accumulation of reserves became well underestimated, and sharp increases in foreign reserves could not be explained solely by the five variables anymore. That is why more specific reasons are next presented in the following four sub-chapters.

These classic explanatory variables were also studied in a working paper by Philip R. Lane and Dominic Burke published in 2001, their data set consisting 102 countries over 1981 – 95. Furthermore, Lane and Burke added external debt variables (total external debt, short term external debt and ratio of short term to total debt) and an oil producing country dummy. What differs from the IMF results above, they found that country size affects in fact negatively on the level of reserves. A smaller and more volatile country is more likely to accumulate large reserves than a big and stable one. This relationship is reversed, however, when restricting the sample to developing countries. The added external debt variables gave a result that external debt has a significantly negative partial correlation with the reserves ratio (Lane & Burke, 2001), and what really matters is the total external debt. One can also think that high debt implies higher opportunity cost to holding reserves, and in that way IMF took external debt into account in its variables as well.

3.2.2 Preparing for the worst

One mostly used reason (IMF, 2003; Gosselin & Parent, 2005)) and at the same time the most neutral one is indeed probably the statement that developing countries are accumulating huge reserves to be prepared for economic turbulence; that is the precautionary motive.

Asian countries remember well the years of crisis only ten years back. Asian financial crisis (which was practically a currency crisis) broke out in 1997 and hit especially hard South Korea, Malaysia, Indonesia, Thailand and the Philippines. Also China, Hong Kong, Singapore, Taiwan and Japan were affected (Barro, 2001) and the crisis spread around

causing somewhat disturbing problems all around East Asia. In South Korea GDP growth rate was -8 % in 1998, same figures for the two other countries I'm analysing are 4 % for Taiwan and 6 % for China[12]. The countries that were most hardly affected by the crisis experienced strong rise in nominal interest rates, large nominal currency depreciations, as well as declining GDP growth, credit ratings and investment ratios. Market's beliefs for long-term growth prospects were diminished fundamentally.

In South Korea, local currency won lost in just weeks' time third of its value against the U.S. dollar in 1997 and while at the end of 1996 one could get 850 wons per dollar, one year later the amount had increased two-fold, to 1700 wons (Federal Reserve foreign exchange rate statistics). In Taiwan, New Taiwan dollar lost one fifth of its value while in China no visible variation can be detected.

That is why countries need foreign currency to weather potential turbulence on currency markets. If a country is hit by a deficit in the balance of payments, it has various options (ECB (2006)):

1) engage in expenditure-switching policies, such as accepting a lower exchange rate, posing import tariffs and quotas
2) impose expenditure-reducing policies, and effectively reduce economic growth
3) engage in policies to stimulate exports
4) finance the deficit by reducing foreign exchange reserves to smooth out short-run payment imbalances.

Typical example of financial market turbulences hitting especially emerging markets is when foreign investors suddenly fear that the currency in question is overvalued and rush to sell it by massive amounts. Large amounts of international reserves can imply that country has a large buffer and they can avoid costly liquidation of assets and that way can demonstrate the commitment to exchange rate stability.

[12] Before the 1997 crisis, in 1995 GDP growth rates for the three countries were as high as 10.9% for China, 9.2% for South Korea and 6.5% for Taiwan (UNCTAD, 2006).

Aftermaths were often done by international organizations, such as International Monetary Fund and The World Bank, which provided last resort loans for countries in distress. Loan terms are often very strict leading countries to decrease public expenditure in a way that sometimes it deteriorates further the economy for a short period of time. Thus countries may wish to reduce their dependence on such organisations, as is clearly the case with South Korea. They obviously don't see conditional borrowing rights at the IMF and own reserves as perfect substitutes but are prepared instead to follow the costly strategy of accumulating large FER.

South Korea blamed the International Monetary Fund for prolonging its economic misery in 1997 – 1998 after draconian measures to be taken in order to get the loan IMF offered. Even though a study by Michael M. Hutchison in 2001 stated that albeit there was a pattern of reduced domestic credit growth in countries participating in IMF programs, no effect on budget policy or for the economic growth *post* crisis in either the short or the long run was detected. However, the Asian crisis is still known in Korea by the name of IMF crisis, and to be protected against a similar situation in the future, Koreans are accumulating huge foreign exchange reserves to be able to preserve liquidity.

Albeit Taiwan was not hit as hard economically during the Asian crisis as Korea did, it has its own reasons behind fast pace of FER accumulation. Taiwan, being officially a part of China, but practically its own state with its own government, money, monetary and fiscal policy needs to have an own and unique strategy when it comes to preparing for bad days. I am addressing more on this subject later on in chapter 4.1.3.

Although reserves may be useful in times of crisis, pace the reserves are being accumulated today have made them more than reach their adequate levels. If they would have been increased for precautionary motives only, the accumulation would have slowed down after the "optimal" level was reached. These adequacy indicators, the Guidotti-Greenspan rule as well as other prevalent rules (chapter 3.1) have well been exceeded.

3.2.3 Increased savings

First and foremost, one obvious cause for having large excess capital with no obvious purpose of use in the case of China is its remarkably high ratio of domestic savings. Country's national saving is the sum of its domestic investment plus the current account balance. Then, when divided by GDP, one can calculate the national saving rate.

Ratio of national savings is also high in South Korea. According to World Bank statistics, ratio has varied between 32% and 38% during the last sixteen years, and was 31% in 2006. In the world scale, aggregate savings rate is around 21%. This rate in China was as high as 50.5% of GDP in 2005 (as in contrast, it was only somewhat above 10 % for United States). Most of the national saving is used for domestic investment, but what exceeds shows up as a current account surplus (7.1% of GDP in 2005). In this way, the rising saving rate is widening China's external imbalance, which in turn leads to trade frictions and upward pressure on the renminbi.

However, the accumulation of foreign exchange reserves has been faster than the piling up of excess savings. For example in 2005, while excess savings were 7.1% of GDP or approximately 160 billion dollars, China altogether bought about 210 billion dollars worth of foreign exchange. Obviously the high savings rate is not the only reason for China's fast accumulation of FER.

To make it more general, in a closed economy, investments would equal domestic savings in each period. But because today virtually every economy is an open one, and the global capital markets are well-working, people from one country can lend capital to those who wish to make investments in any other country. Because savings can cross national borders, the excess savings can be shifted to the international capital markets. As Bernanke (2005) puts it, main reason for the huge current account deficit U.S. is experiencing today is excess savings in the developing and some industrialized economies as well, or "the global saving glut".

Industrialized countries are experiencing a massive demographic change, with elderly being a majority and that makes countries want to save more for the future bills. Developing countries wanted to have more security from turbulent capital and foreign exchange markets and thus started to accumulate foreign exchange reserves. In order to do that, they needed savings, which they drew from domestic markets through the expedient of issuing debt to their citizens.

This increased supply of savings then boosted U.S. equity values during the stock market boom and helped to increase U.S. home values so that it made people so secure it lowered national saving and that contributed to the nation's rising current account deficit. Reasons for other countries investing in the United States were its high degree of technology, low political risk, strong property rights and good regulatory environment.

This point of view taken by Dr. Bernanke in 2005 states that the accumulation of foreign exchange reserves by developing countries is purely due to the fact of excess domestic savings and increasingly limited investment opportunities at home. He also noted that as soon as developing economies find their reserves adequate, their accumulation should slow down. I have to disagree, albeit I am doing it two years later and have the advantage of knowing recent statistics. Reserves today have greatly exceeded their "adequate" levels, and there has to be another reason than just brace oneself for rough times. Also, the dollar holdings have lost much of their profitability experienced earlier, and for transition economies wanting to continuously keep up buying U.S. dollars must be another reason than just a good investment project.

3.2.4 Drawing cheap loan

While large foreign exchange reserves mean more credibility and stability to a central bank and thus to the economy in transition as a whole, it also increases international credit ratings allowing the country to get foreign loan easier and cheaper than it otherwise would.

Landell-Mills (1988) concentrated on the vulnerability of reserve holdings to international financial market conditions, but on a slightly different point of view. He stated that surplus countries may, because of good credit rating, add to their reserves when investment conditions are good, while deficit countries with increasing real resources absorbed by debt repayments will be forced to borrow at a premium to maintain desired reserve levels. Alternative viewpoints exist because of different ways of thinking about the cause and effect relationship.

While credit ratings become more favourable it boosts foreign direct investments into the country when the risk decreases. On the other hand of course the economy must otherwise be stable too, in terms of social and physical infrastructure, definitely with no excessive problem with corruption or government disorders.

As can be seen from the sovereign rating history by Moody's and Standard & Poor's, the ratings have not become that much higher for countries with large foreign exchange reserves during these recent years, although the difference between other countries in Asia is substantial.

Ratings from 2003 to 2007 can be detected from figures 20a-d in Annex 1, derived from Asian Development Bank's Asia Economic Monitor 2007, p.16[13]. When comparing figures 20a to d it is obvious that China, Korea, Taiwan, Singapore and Hong Kong have very different sovereign ratings than rest of Asia (Malaysia, Thailand, Viet Nam, Philippines and Indonesia). Standard & Poor's rated China as A alongside with Korea, whereas Taiwan was AA- in November 2007. Taiwan has retained its sovereign rating position during the whole period, while Korea improved its position with one notch and China moved all the way from BBB in 2003.

According to Moody's, Korea moved from A3 in 2003 to A2 in 2007, China improved its position gradually from A3 to A1 while Taiwan rated as Aa3 during the whole period. Singapore was rated Aaa and Hong Kong Aa2, but all the other Asian countries were far

[13] ADB- Asia Economic Monitor 2007 available at http://www.aric.adb.org

behind, best being Malaysia reaching A3 in 2007. Both of the two international credit rating companies placed China and Korea in the group of 'modest risk and good financial security', while Taiwan is rated as 'minimal risk, excellent financial security'.[14]

The ratings of the three countries in question have been substantially higher in the 21st century than other countries in Asia or other transition economies in Latin America or Eastern Europe, but because they were higher already prior to the FER accumulation it can not be the sole source of increased solidity and credibility. Excessive accumulation of foreign exchange however enhances countries' financial stability and the ability to respond to real economy imbalances, which can be one reason for higher ratings.

While risk free sovereign rating allows countries to draw cheaper loan from abroad, it also boosts foreign direct investments while companies feel safer to invest large sums of money in business developments in a country with good financial stability. It also enhances cooperation between foreign and domestic operations and gives credibility for the country as a whole. As an example from the adverse effect I take Canada and its experience with Moody's Investors Service in late February 1995 (Washington Post 2004).

Moody's placed Canada's debt at the beginning of 1995 "on review for a possible downgrade" – a signal that it was concerned about the country's finances. News spun fast around the world, and almost instantly the Canadian dollar dropped by about a half-cent against the U.S. dollar. The central bank tried to stop the slide by buying back several hundred million dollars of its money. Investors dumped Canada's bonds and drove their interest rates higher, which did cost the government hundreds of millions of dollars. The warning by Moody's (the actual downgrade became later) was enough to roil financial markets and send even a major and stable sovereign nation fighting to restore order.

From that viewpoint it is not a surprise that economies in transition want to acquire the stability international credit rating companies can provide. One way to do so is obviously

[14] For more detailed description and order of the used ratings, look at Table 5, p.100 (Annex 1)

accumulate strong reserves of foreign exchange which protect a country from financial instability. Albeit it is not a final cure, while credit rating changes can also happen for other reasons that large foreign exchange reserves can not contribute to. That being said, if even a stable and prosperous country like Canada is being hit by lack of confidence, accumulation of foreign exchange reserves can not do any harm for more unsustainable countries in that matter.

In a survey by Bank for International Settlements (Mohanty & Turner, 2006) on the impact of reserve accumulation on credit ratings and external vulnerability of central banks in emerging markets, all 16 central banks who responded believed that reserve accumulation had some positive effect on sovereign credit ratings. Only in Columbia did the credit ratings not improve during periods of FER accumulation. Several central banks – in both fixed and floating rate regimes – commented that higher reserves gave them greater confidence and credibility in foreign exchange markets. They observed that it helped to improve the sustainability of their external positions and hence their credit ratings. It also reduced international funding costs in a number of emerging economies.

3.2.5 Tampering with exchange rates

Some countries have kept their currencies undervalued in an effort to maintain external competitiveness, attract foreign direct investment and boost exports and growth. While more and more countries are claiming to let their currency float freely, a working paper by Guillermo Calvo and Carmen Reinhart (2000) states that the actual fear of floating is pervasive even among some developed countries, and one must not take for granted the official exchange rate regime especially economies in transition and developing countries are claiming to adopt.

Poorly managed exchange rates can be disastrous for economic growth. Avoiding overvaluation of the currency is one of the most robust imperatives that can be gleaned from the diverse experience with economic growth around the world, and it is one that

appears to be strongly supported by cross-country statistical evidence (Rodrik, 2007). Rodrik graphed in the paper side-by-side his measure of real exchange rate undervaluation against economic growth rate in corresponding period for seven countries during 1950-2004 including South Korea, Taiwan and China. In China, economic growth tracks the movements of undervaluation to a high degree. The results for the two East Asian tigers, Korea and Taiwan, are similar. The growth slowdowns in recent years (the first years of the 21st century) were in each case accompanied by growing overvaluation or reduced undervaluation.

While accumulating large foreign exchange reserves, a country is consistently selling domestic currency and buying foreign currency that is increasing the demand for foreign currency and the supply for domestic one. Thus it increases the nominal exchange rate and taking price levels in the two countries as given, also the real exchange rate increases which in turn keeps the trade balance in surplus. At least, (because a big part of foreign exchange interventions are being sterilized) it keeps the exchange rate from *decreasing*. As I already stated, this is the biggest reason European and American governments are blaming China for accumulating large FER.

Like said in chapter 2.2, when for ex. USD/KRW exchange rate is high, Korean goods are relatively cheaper than American ones, and the demand for Korean goods in United States increases. When it does, so does the demand for wons, since Americans need to have Korean currency in order to pay for their exports. Increasing demand for wons makes the exchange rate decrease and won to appreciate, which puts trade surplus back in balance. Now, if the Koreans would tamper with exchange rates by keeping the supply of wons up as well as the demand for dollars, exchange rate would not change while trade surplus would maintain.

Dooley, Falkerts-Landau and Garber (2003) argue that normal evolution of international monetary system involves the emergence of a periphery for which the development strategy is export-led growth supported by undervalued exchange rates, capital controls and official capital outflows in the form of accumulation of reserve asset claims on the

"centre country", which they state is the United States, as it was during the initial Bretton Woods system.

World is pictured to be divided into three different functional zones; a trade account region (Asia), a centre country (U.S.A), and a capital account region (Europe, Canada and Latin America) (Dooley, Falkerts-Landau & Garber, 2003). As a trade account region, exporting to the US is Asia's main concern. Exports mean growth. When their imports do not keep up, official sectors are happy to buy U.S. securities to finance the shortfall directly, without regard to the risk/return characteristics of the securities. Their appetite for such investments is, for all practical purposes, unlimited because their growth capacity is far from its limit. An alternative is to target imports of capital goods from United States, which they would do if they came under commercial policy pressure.

According to these three economists, there is a rising volume of complaints in the U.S. about the unfair trade advantages of Asia's undervalued currencies, aimed primarily at China, but curiously not at Japan, whose goods are more directly competitive with manufactured goods in the United States. Asia's eagerness to hold dollar denominated assets does not reflect an irrational affinity for the U.S., since Asia would export anywhere if it could and happily finance any resulting imbalances. What is noteworthy is that the US is open, Europe is not. Europe could not absorb the flood of goods given its structural problems and in the face of absorbing East Europe as well. So Asia's exports go to the United States, as does its finance; otherwise US, if faced with financing difficulties might similarly tend toward more stringent commercial policy. Asian officials are reluctant to shift toward Euro assets because of the depressing effect this would have on trade with the U.S. (Dooley, Falkerts-Landau & Garber, 2003).

Other reason for keeping exchange rates favourable is to attract foreign investment. Equation 1 in page 9, the interest parity condition, states that foreign interest rate must equal domestic interest rate plus the expected change in the nominal exchange rate. Outcome depends thus fully on what investors believe to happen in the future, e.g. what are their expectations. If the Bank of Korea could make investors believe, that it can keep

(through foreign exchange interventions) the won appreciating against U.S. dollar for quite a long time; investors would then expect the dollar/won exchange rate to keep increasing in the future. This would mean that taken the interest rates in U.S. and Korea as given, the rate of return in Korea would be higher for international investors than that in the United States. This is one way to attract foreign investments and to not have to raise domestic interest rate unreasonably high (that would be another simple way of making foreign investing more attractive inside a country)[15].

Whether accumulating foreign exchange reserves is because of preparing oneself for the poor times, to be able to attract more foreign capital, cheaper loan, keep exports blooming or just because of the domestic situation that there is simply too much savings with no reasonable use, there still has to be some payback behind such behaviour. The simplest but also the scariest one from recent literature and discourse comes here: power. While China for example owns foreign exchange almost worth of 1.5 trillion dollars, world leaders have to pay attention to and listen more respectfully what the Chinese say than they have done in the past. The country now sure has the money and the ability to shake international financial and real balances.

[15] This is actually what South Korea did after the currency crisis in 1997. When almost 2 billion of foreign capital had escaped the country in a few weeks time, Bank of Korea raised interest rate from 10-12% range in the pre-crisis period to 25-30% range in post-crisis period in order to keep the still prevailing money inside country boarders. When interest rate is as high as that, it starts eventually to damage domestic investment and aggregate demand. (Lee, 2000)

4. Empirical analysis

As already stated, the three economies I am going to focus in my attempt to find evidence on paybacks economies in transition must have been getting out of the strategy of accumulating large FER are China, South Korea and Taiwan. I first go over some details about their current and past monetary policy and exchange rate regime, and then focus on specific aspects of their current macroeconomic situation. At the end of this chapter I present results from the multiple regression analysis I performed for these three countries for years 1990-2006, and assess differences in motives for acquiring large foreign exchange reserves across time.

4.1 Overview of the monetary policies

In this fourth chapter I first go over the three countries I am going to address more in the rest of my thesis by describing their central banks' monetary policy. Data is taken from the central banks homepages where they all publish annual and monthly reports of their monetary policy conduct and economic situation. They all claim to have more or less a freely floating exchange rate system, which in reality does not entirely hold true. In a study by Terada-Hagiwara (2005) is reported that China's monetary policy framework is based on an exchange rate anchor with monetary aggregate target. As with South Korea, Bank of Korea aims at inflation targeting while Taiwan explicitly tries to affect monetary aggregate target (M2).

4.1.1 China and People's Bank of China (PBC)

According to the IMF International Financial Statistics, China has foreign exchange reserves of the size of 1,530 billion dollars in November 2007. It is more than the market value of each and every company in the Nordic Stock Exchange OMX combined (which is worth about 1,200 billion U.S. dollars). This amount of more than 1.5 trillion dollars is the

actual foreign exchange reserve, i.e. gold is excluded. Accumulation has been immensely fast. In 2000, the foreign exchange reserve was only about one tenth of what it is today, 168.3 billion dollars. Predictions state (dbresearch, 2008) that FER would attain 1,600 million in 2008 and further climb to 1,725 million in 2009, which however could be an understatement if accumulation keeps its current space.

People's Bank of China (PBC) states in its monetary policy report published earlier this year (PBC, 2007), that it will follow the overall strategy of the Central Government, giving the highest priority to macro-economic adjustment efforts to constrain the economy from growing relatively fast to overheating. It will continue to make the necessary policy adjustments to maintain a stable monetary environment, to control inflation expectations, and to maintain overall price stability. PBC also informs that it will continue to follow the policy of improving the renminbi (RMB) exchange rate formation mechanism in a self-initiated, controllable, and gradual manner, further giving market supply and demand a fundamental role in the RMB exchange rate formation, strengthening the RMB exchange rate flexibility, and maintaining it at an adaptive and equilibrium level. PBC's explicitly stated money supply target was 16% in 2007, which was exceeded by the actual monetary aggregate M2 growth rate in the last months of the year (ADB Asian Economic monitor 2007).

Exchange rate shall also be given a more active role in adjusting balance of payments, which showed a huge surplus in the first half of 2007. The official foreign exchange reserves were growing fast, and surplus was bigger than measured in previous year. Balance of payments registered surplus and so did international trade – growth of exports remained again higher than growth of imports and thus trade surplus continued to widen.

From early 1970s', China began to list an effective rate, which was later pegged to a trade-weighted basket of 15 currencies, for foreign exchange transactions (The Chinese University of Hong Kong, 2000a). While starting to open up, China created a multiple rate structure in the early 1980s' followed by a controlled float depending on changes in Chinese balance of payments as well as costs and exchange rates of China's major

competitors and trading partners. In 1990s' PBC moved towards market orientation and allowed the renminbi exchange rate to adjust more frequently.

On July 21st 2005 China adopted a managed float exchange rate regime based on market demand and supply with reference to a basket of currencies. However, the weights attached to each currency were not revealed (Funke & Gronwald, 2008). Before, RMB was pegged only to U.S. dollar with periodical adjustments according to fluctuations in the exchange rate of the dollar. New exchange rate regime being implemented roughly two years now, there has been a steady tendency of renminbi appreciation against U.S. dollar and Japanese yen. The RMB against yen witnessed largest appreciation, with an accumulated appreciation of 20 % in two years, while that of USD was the second largest, 10 % in two years.

While PBC does not state officially any explicit reason or specific use for its huge foreign exchange reserves, it altogether criticizes the way United States handles the bilateral situation. In its monetary report it informs how U.S. Treasury Department releasing its latest Exchange Rate Policy Report (on June 13, 2007) explicitly stated, for the first time ever (as the Chinese point out) that the renminbi is undervalued. The PBC Monetary Report blames U.S. officials for strengthening the trend of protectionism in world trade, and says that simply due globalization, trade frictions among countries are a normal phenomenon.

That is, officially there is no reason why PBC (in straight control of the government of China) is accumulating its foreign exchange reserves at full speed, albeit it founds its monetary policy on foreign exchange rate anchor. We must turn to reasons stated for example in recent literature (chapter 3.2) and try to figure out what that is that gives cause for such a strategy.

4.1.2 South Korea and Bank of Korea (BOK)

South Korean won was pegged to U.S. dollar from May 1964 until March 1980, when a controlled, floating Effective Rate was being introduced. After sixteen years of single currency peg against the U.S. dollar, multiple currency basket peg system was adopted and won was linked in a combination of currencies of South Korea's major trading partners, namely U.S., Japan, Germany and Canada. Again in 1990, Effective Rate was replaced by a market average rate which was a managed float exchange rate regime, where the exchange rate was determined by market forces in interbank market; the Seoul Foreign Exchange Market. (The Chinese University of Hong Kong, 2000b).

After turmoil in Thailand in 1997, currency crisis started to spread around South-East Asia, and let also South Korea affected. Korean won was attacked by speculators, foreign capital flew off the country and national currency lost almost 40 % of its value in just a few weeks time. The South Korean government tried at first to widen the won trading band (from ±2.25% to ±10%), but finally in December 1997 had to allow won to float freely.

Foreign exchange reserves for South Korea were 96.3 billion dollars in 2000, while today (January 2008) they have grown to 261.9 billion dollars. Bank of Korea (BOK) states in its monetary policy report (BOK, 2007) from September that the reason why its foreign exchange reserves have been rising comparing to the end of the previous year (by 16.3 billion dollars) is mainly the improved earnings from the operation of reserves and the conversion effect for non-dollar assets arising from the dollar's weakness. In August 2007, the composition of Korea's FER was 87.1% securities holdings, 12.8% deposits and 0.1% country's reserve position with the IMF.

Bank of Korea's aim is to keep a close watch on price stability, but at the same time conduct monetary policy taking business activities and financial market conditions into overall consideration. It will unceasingly monitor international financial market

movements, and take prompt action through open market operations if signs of unrest emerge in domestic or international financial markets. Bank of Korea has set an inflation target range of 2.5-3.5 percent for 2007 till 2009.

In 2005 South Korea's Prime Minister Lee Hae-chan said in a speech at a seminar at the end of March that the country's foreign exchange reserves were well over their "appropriate level", which he estimated to be around 150-170 billion dollars. He warned that while they are about 30-50 billion dollars above the desirable level, negative side-effects can occur and it would be time to consider how to manage the excess reserves in global market (Taipei Times, 2005).

In 2006, criticism arouse in South Korea because of the huge foreign exchange reserves, which were invested largely in U.S. Treasury Bonds, low-yield investment in general and vulnerable to the unstable dollar. Thus the Bank of Korea and Ministry of Finance made a contract with Korea Investment Corp.[16] permitting it to invest and use South Korea's FER more efficiently (Forbes, 2005). The fund received 20 billion dollars as seeds money, which it then has invested through its global assets managers. By law, Korea Investment Corp. can invest in stocks, bonds, foreign currency, derivatives, and real estate. However, guidelines set by the Bank of Korea and Ministry of Finance will undoubtedly band it to invest in properties or derivatives to keep it from taking excessive risk.

South Korea is thus trying to have also profitability out of its huge reserves; while domestic opponents think FER should only exist for liquidity and stability and not be risked in any way. One considerable aspect is the current political situation on the peninsula. Kim Jong-Il, North Korea's leader has already started to show some signs of possible reunification in the future by making several concessions never seen before. South Korea needs thus to maintain substantial reserves to help finance the eventual reconstruction of North Korea, if and when the latter collapses. The cost of reconstruction depends on the time frame and is estimated at anywhere between a couple of hundred

[16] Korea Investment Corp. is a government-owned investment management company, specializing in overseas investments. In order to maximize efficiency of its investment, KIC has been designed to be run commercially and independently. [derived from KIC homepage, www.kic.go.kr]

billion dollars to two trillion dollars, which would currently correspond to 20% - 200% of South Korea's GDP (EMM, 2007).

4.1.3 Taiwan and the Central Bank of the Republic of China (Taiwan)

Central Bank of the Republic of China (Taiwan) was first established in Shanghai in 1923 by Dr. Sun Yat-Sen, in order to finance national development. The Republic of China (referred sometimes just as Taiwan, term I am using throughout my thesis) and mainland China (People's Republic of China) went through civil war, and as a result, the Republic of China moved to administrate in the island of Taiwan. The Central Bank is today nation's sole monetary authority in Taiwan. The Bank conducts monetary and foreign exchange policy, issues nation's currency, and serves as the bank of banks and the government's bank. Taiwan formally adopted a managed float exchange rate system in 1979, the same time that Taipei Foreign Exchange Market was established. Under this exchange rate regime, NT dollar (New Taiwan dollar, Taiwan's national currency) exchange rate is determined, in principle, by market supply and demand. However, if the market is being disrupted by seasonal or irregular factors, the Bank will step in (Central Bank of China (Taiwan), 2007).

Consistent with Taiwan's economic development, its financial system has been gradually transformed into a more liberalized one. In the 1960s', with a trade deficit and shortage of foreign exchange, Taiwan adopted foreign exchange control and an exchange rate system fixed to U.S. dollar. It wasn't until July 1978 when the link of the NT dollar to U.S. dollar was abandoned and a managed foreign exchange regime was adopted by creating an effective rate, which was periodically revised against Japanese yen, South Korean won and U.S. dollar. Two years later, in February 1979, the effective rate of new Taiwan dollar was placed on a controlled floating with its exchange value being determined against a basket of currencies which included the U.S. dollar, Japanese yen, Deutsche mark, Hong Kong dollar, Singapore dollar, U.K. pound sterling and French franc. Finally in 1989 an interbank foreign exchange market was established and in April same year the NT dollar

was set free to float according to supply and demand (The Chinese University of Hong Kong, 2000c).

With respect to the capital account, foreign exchange transactions not involving the NT dollar are completely deregulated. Foreign exchange transactions involving the NT dollar but supported by transactions of goods and services, direct investment, and approved portfolio investment are also liberalized. Some limits on other forms of short-term capital flows are still in place. As the Bank puts it, the level of Taiwan's foreign exchange reserves is among the highest in the world. FER are important national assets, which provide security, liquidity, and profitability. Derived from the Bank's homepage, in addition to the basic principles of maintaining the three things stated previously, in recent years utilization of FER has also been dedicated to promote economic and industrial upgrading. For this purpose, the Bank has adopted three measures:

1) Through the foreign exchange market, the Bank appropriates the funds needed by domestic enterprises to import major items of machinery and equipment

2) The Bank has already appropriated USD 20 billion, EUR 1 billion, and JPY 60 billion as seed funds for the Taipei foreign currency call-loan market. This market has also established a computerized network system with brokerage firms in major international financial centres

3) The Bank has deposited a portion of its FER in the overseas branches of their domestic banks to promote international financial activities and to support the Taiwanese firms located there

US dollars account for a major share of total reserves, followed by the Euro and the Japanese Yen. This composition is similar to those of other major central banks around the world. (Central Bank of the Republic of China (Taiwan) (2007)).

Taiwan thus explains its accumulation being due to promote its international activity, liquidity and security. The aspect it doesn't say upfront is the unsettled political status which continues to be a contentious issue. Taiwan views itself as an independent sovereign state, while mainland China claims it to be illegitimate, and refers to it as China's province. Because of mainland China's One-China policy, it only participates in

international organizations where Taiwan is not recognized as a sovereign country. That is why organizations such as IMF or World Bank do not recognize Taiwan as a state (Taiwan was expelled from both World Bank and the International Monetary Fund in April 1980 after 24 years of membership). Here lies the problem then: during a possible economic crisis, there will practically be no one helping out, no international lender of last resort and Taiwan would probably become fully dependent on mainland China. That is why Taiwan has adopted wittingly the strategy of accumulating its own strong foreign exchange reserves.

Currently (January 2008) Taiwan has foreign exchange reserves the size of 272.8 billion U.S. dollars, while in 1990 it was of 72 billion and in 1980 only just above 2 billion. The growth rate of foreign exchange reserves was on average 11.5 % (y-to-y %-change) between 1990 and 1997, while in the 21st century, between the years 2000 and 2007 (February), pace has been more than twice as fast (25.1 % on average). Taiwan's estimated GDP in 2007 is 376 billion dollars, which means that its FER counts as much as 70 % of its annual gross domestic product.

4.2 Macroeconomic situation

Let us now turn to the overall economic situations of the three countries and view them through some indicators dealt with in literature covering the fast accumulation of foreign exchange reserves. I am concentrating here on the formation of exchange rate, inflation, international trade, credit lending and banking sector in general, investments from and towards abroad as well as external debts (short and long term). Figures can be found in Annex 2.

4.2.1 Exchange rates and inflation

I am now addressing China's, South Korea's and Taiwan's domestic macroeconomic indicators, such as foreign exchange rates, foreign trade and inflation developments over

the past decades and consider them through the current fast accumulation of foreign official reserves. The rest of this sub-chapter is divided in three parts, separately studying each of the three countries.

China

After 2002, foreign exchange reserves growth rate has surpassed the monetary aggregate growth rate in China at least by 12 percentage points annually and in 2004 foreign exchange reserves grew 35 percentage points faster than money supply (figure 8). While the median return on foreign reserves has been declining and most countries were experiencing losses on their reserves after year 2002 (Hauner, 2005, see also chapter 5.2.2), the expansion of foreign exchange reserves in recent years has to be the result of accumulating further reserves and not of increase in net worth. It follows that most of the foreign exchange market interventions Chinese monetary authorities have committed have had to been sterilized ones; in order not to cause unnecessarily domestic monetary expansion. Reserves per money supply (M2) -ratio has been growing fast from 3.6% in 1993 to 26.5% in 2007. That is, more than one fourth of domestic renminbi supply is backed by foreign exchange reserves, making the Chinese currency well protected.

Increase in foreign exchange reserves is also due to the fact that Chinese trade balance has been on surplus for more than the past decade (see figure 11) while foreign exchange rate – presented in figure 12 is the exchange rate between U.S. dollar and renminbi – has remained stable. Like stated in chapter 2.2, when there exists imbalances in IS-LM-Z markets, exchange rate fluctuations bring them eventually back to balance. Now in the case of China, while trade balance surplus has persisted without exchange rate adjustments, one can conclude rather clearly that monetary authorities have intervened in foreign exchange market in order to keep economic indicators where wanted. Some sign of renminbi appreciation has appeared recently but so modest that it does not affect trade balance restrictively, instead trade balance surplus (counted as percentage of imports) has further increased after 2004.

Inflation has remained relatively stable and remarkably low taking into account the huge economic growth rate (more than 10% GDP growth) China has experienced in last years (see figure 12 for inflation rates). In 2007 inflation rate was 5.7% and IMF (World Economic Outlook, 2007) estimates that it would decline to 3.5% during 2008.

Remembering chapter 2.1 and effects exchange rates have on real economy I can conclude that People's Bank of China keeps on accumulating foreign exchange reserves to stabilize exchange rate expectations, exchange rate being its monetary policy anchor (see Ch. 4.1.1). While no appreciation - nor depreciation for that matter - is anticipated in the future, there is no change in foreign exchange rate at present either and that strongly anchors interest rates as well, even if PBC has not explicitly declared in targeting interest rates while conducting its monetary policy. Foreign reserves accumulation thus plays an important role in strengthening monetary authorities' credibility in emerging markets.

China's interest rates (figure 13) have come down and stayed under two-digit levels since 2004. While they still are higher compared to Europe and rest of the developed world, they are substantially lower than in 1990's. Real exchange rate has stayed relatively stable since 1996 (figure 14). Resulting from steady exchange rate and price level, terms of trade has not experienced much of a change and China's exports keep on blooming.

As can be seen from figure 15 China's growth rate of openness for foreign trade (its aggregate foreign trade to GDP –ratio) follows quite closely the growth rate of relative size of foreign exchange reserves (FER/GDP –ratio). They are viewed at opposite scales, but one can clearly note that after Asian crisis in 1997 growth rates have become more similar. In 1990, China's imports and exports together were about 30% of country's GDP, while in 2006 they accounted already for almost 70%. Relative size of foreign reserves was only 15% at the beginning of 1990's, but increased to over 40% in 2006.

In China, when judging by the eye, export volatility has been growing alongside with foreign trade openness and FER/GDP –ratio. As a measure of export volatility I am using here five year lagged standard deviation. Measured as such, export volatility was rather

stable until 21st century when it started to grow quite fast, as is somewhat the case with all of these three countries (figures 15 to 17).

South Korea

In South Korea, both foreign reserves growth and money supply growth rates have been overall more volatile than in China. However, after economic crisis in 1997, foreign exchange reserves have been growing every year by more than 10% and have exceeded monetary aggregate M2 growth rate annually (see figure 6). In 1999 reserves were increased by almost 60% while money supply growth stayed at 5% level. Again in 2004 reserves grew by 30% compared to M2 growth rate of 5%. Referring to Hauner (2005) as with China above, foreign exchange interventions Bank of Korea has been carrying out must have been sterilized to a great extent. Reserves to M2 –ratio stayed fairly stable until economic crisis in 1997 (around 6%). Thereafter it started to increase and reached 20% in 2005.

South Korea's exchange rate was relatively stable before crisis of 1997 (see figure 9) when it jumped up and won depreciated in an unprecedented scale. I have constructed two curves of trade balance, where one is done by lagging observations for one period. Exchange rate changes do not affect trade flows immediately but they develop rather a bit behind, and in the case of Korea lagged curve of trade balance follows somewhat closely the curve of exchange rate changes. When exchange rate change curve is above zero, won depreciates which leads trade balance to amend and vice versa. Before 1997 South Korea experienced trade balance deficit annually, but post-crisis balance has been positive. After 2001 won has experienced some appreciation, which has led trade balance to deteriorate although it still has stayed positive.

As can be seen from figure 12, inflation rate was above 5% during almost all of 1990's, nearly reaching double digit figures in 1990 and 1991. Inflation started to decrease after Korea recovered from the economic crisis and has stayed fairly stable since. BOK introduced inflation targeting as means of monetary policy and it has had a visible impact. In 2007 inflation rate was 3% and is forecasted to decrease to 2.7% (IMF) in 2008. It is

between the band pursued by BOK, which was set to 2.5-3.5% for 2007-2009. Large foreign exchange reserves are undoubtedly one reason behind central bank's credibility when targeting low inflation rates and economic stability. Interest rates were somewhat high and volatile before 1998 when they decreased to 5% and have stayed below since (figure 13). Korea's terms of trade increased after crisis but has been decreasing again since 2002, real exchange rate growing annually thereafter, which boosts exports.

Because of country's growth strategy has been export promotion since as early as 1960's; South Korea is highly dependent on foreign trade (figure 17). Ratio of foreign trade to GDP was already over 50% in 1990 and increased steadily since, being close to 80% in 2006. FER were only close to 5% in proportion to national GDP 16 years ago, while in 2006 share is over 25%. Growth rate of FER accumulation followed closely the growth rate of GDP, curve being fairly smooth until 1997 but thereafter accumulation has been fast. Export volatility (5 year standard deviation) in South Korea is rather similar looking curve when compared with that of Taiwan (figure 16). Export volatility grew in years of crisis (1995-1998), reduced thereafter, but began to rise again rapidly after 2002.

Taiwan

In Taiwan (figure 7) growth rate of M2 has smoothly decreased during the last two decades. It has come down from 20% to 10% per year. Foreign exchange reserves showed a quite modest growth until 1998; thereafter growing by more than 15% a year for the exception of year 2000. Reserves per M2 –ratio has been far higher in Taiwan than in China or South Korea throughout the recent decades. In 1991 ratio was already almost 29%, but it started to decrease and in 1996 it was at its lowest value, 17.3%. Thereafter it continued to increase again and reached 33.6% in 2006. That is, one third of New Taiwan dollar supply is backed by foreign exchange reserves by the central bank which surely brings credibility and trustworthiness for a minor currency, as can be also detected from its lack of volatility.

As can be seen from figure 10, annual exchange rate changes have stayed between a ±5 percentage point band through 1990's and the first five years of 21st century with the

exception of Asian crisis in 1997, when New Taiwan dollar lost one fifth of its value against U.S. dollar in a short period of time. All in all, foreign exchange rate is fairly stable in a still emerging economy, which highly depends on foreign trade. One reason surely is the high ratio of FER to GDP (see figure 10, also further discussed below), and central bank interventions in foreign exchange market.

When lagging trade balance by one period, it is obvious how it follows the development of exchange rate change throughout the years, excluding 1997 when simultaneously trade surplus decreased with exchange rate depreciation. Trade balance has stayed positive annually since 1991 and is currently increasing, being over 10% of imports in 2005. Inflation rate (figure 12) has come down from its 5% level – where it stayed between 1991 and 1996 – and has been relatively small since, attaining 1.7% in 2007 and decreasing further to 1.5% during 2008 (IMF estimations).

Inflation has stayed really low in Taiwan, also when compared to Europe and other developed countries with explicit inflation targets. Interest rates are a smooth curve as well, further decreasing after 2000. Real exchange rate has been decreasing for the past two decades, ameliorating Taiwan's terms of trade.

Taiwan has been highly dependent on foreign trade, being such a small state and also due to the fact that it trades a lot with mainland China and Hong Kong. In 1990 imports and exports combined reached 80% of GDP, and by 2006 it grew to 120%. FER/GDP –ratio was over 40% already in 1990, thereafter however decreasing until 1997 when it started to rise further and is currently reaching 80%. Export volatility in Taiwan follows the same path as the one in Korea (figure 16). Export volatility grew during the Asian crisis, and started to grow again in 2002, growth rate being really fast since. Such volatility in exports for such a small economy with high dependency ratio on foreign trade is surely one factor in explaining the current hoarding of foreign exchange on central bank's balance sheet.

4.2.2 Size of the economy and implications on different markets

One classic explanatory variable was the size of the economy (chapter 3.2.1). As such, we should see a positive correlation between countries' gross domestic product per capita and their foreign exchange reserves accumulation. As can be detected from figures 18-20 the amount of total population can not be taken as a factor, since it alters too slowly. GDP per capita is indeed a fair variable in the case of China, but clearly it can not be generalized, judging by Taiwan and Korea.

As a curiosity, every time GDP per capita decreases substantially between 1990 and 2007 for the three economies, it is followed by a strong increase in relative size of foreign exchange reserves (FER / GDP –ratio). This is the case with China in 1993-1994; Taiwan in 1997-1998 and again in 2000-2001; and Korea in 1996-1998. Increase as strong implies strong accumulation of foreign exchange reserves, not just an increase of the ratio due to a lower GDP. It would imply that after economic shocks central banks tend to further accumulate their liquidity and smoothing the accumulation further they get from the negative shock[17].

Figures 21-23 detect the financial openness China, Korea and Taiwan have been experiencing since 1990. Financial globalization is at present introduced as a prevailing reason for emerging markets' accumulation of liquidity in the form of foreign exchange reserves. Judging by the eye, it indeed seems that FER/GDP and M2/GDP curves are moving at the same direction, especially since 1997. M2/GDP is a broadly used proxy for financial globalization, detecting the increase of moving capital flows (Aizenman & Lee, 2005).

Exchange rate volatility is (as with exports earlier) measured by taking an average five year standard deviation. This volatility was one of the classic explanatory variables introduced in chapter 3.2.1. Effect was reasoned to be negative; higher exchange rate

[17] This negative relationship can be detected formally from the multiple regression analysis I conduct in chapter 4.3, see also table 6 in page 105.

volatility indicates more freely floating exchange rates which decreases the need for foreign exchange reserves. With Korea and China the exchange rate volatility increased between 1993 and 1996 (China) and between 1996 and 2002 (Korea) which in fact further increased foreign exchange reserves hoardings. Since then, volatility has substantially decreased. With Taiwan, exchange rate volatility has increased more or less steadily since 1990 alongside with foreign exchange accumulation. Perhaps one reason for acquiring large reserves is in fact the fear of volatile exchange rates deteriorating country's external position, as Calvo and Reinhart pointed out (Calvo % Reinhart, 2000).

Banks, and not the non-banking private sector, have been the primary counterparty to the expansion of central bank and government securities used in order to stabilize monetary expansion while acquiring more foreign exchange on central banks' balance sheets (Mohanty & Turner, 2006). In China, for instance, 80% of central bank securities were held by banks at the end of 2005. To the extent that banks with such liquid assets feel better placed to expand credit, the restraining influence of sterilized intervention on monetary growth could prove temporary. Another challenge is that a large stock of sterilisation securities and other forms of interest bearing non-monetary liabilities increases the interest payment liabilities of central banks, requiring further issuance of securities.

Nevertheless, reserve accumulation in a number of countries has been associated with easier financing conditions, bank lending rising strongly in several countries. Large-scale issuance of sterilisation-related debts might also affect the development of the private bond market, as a larger supply of risk-free central bank debt crowds out private sector issuance. In figure 27 I present the development of credit lending (for public) for China, Taiwan, and Korea in 1990-2006.

Domestic credit has not in fact grown that much when taking as ratio to GDP. The ratio has stayed rather stable the last ten years for all of the three countries in question. It was not until 1997 when the ratio for China crossed 100%, while with Taiwan it has been over 120% for almost two decades now. At present, the ratio is about 170% in Taiwan, 160% in

South Korea and around 120% in China. As such it does not seem to have a close relationship with reserve accumulation[18].

4.2.3 More capital from abroad; investments and external debts

How do foreign exchange reserves affect country's burden of debt then? Or is it the other way around; are large foreign exchange reserves the consequence of excessive debt taking?

From figures (24-26) I could derive that the more China, Taiwan and South Korea have been accumulating foreign exchange reserves after 1990, the more their external debt taking (and especially short-term debt) has increased[19]. In China, overall debt taking has remained stable in proportion with GDP growth (see figure 24) but the share of short term debt from total debt has increased from about 25% to more than 50%.

In South Korea however, while also external debt to GDP –ratio has remained rather intact the past decades, the share of short-term debt from total external debt has in fact been reduced drastically from around 60% to close to 40% (figure 26). While the share of short-term debt has decreased, South Korea has been accumulating its long term external debt taking alongside with foreign exchange reserves. Before 1997 crisis, ratios FER to GDP and total debt to GDP had been stable, but thereafter FER/GDP has increased drastically (figure 25) while relative external debt burden has remained somewhat same as before.

Taiwan is a bit of an exemption from the previous two. Its overall debt taking (total external debt to GDP –ratio) has been increasing from 12.9% to 22.6% during the past nine years, following very closely the development of the ratio of foreign reserves to GDP. Short-term debt relative to overall external debt has not increased or decreased substantially, ratio has grown from 81% to 87%; however it is very high compared to the

[18] I am later estimating also domestic credit in the multiple regression models, results being somewhat contradictory between the three models.
[19] This is in fact true according to the results of the regression models (see chapter 4.3.2 and annex 3)

other two Asian countries. Taiwan increases short-term and long term debt relatively at almost same pace, and simultaneously strengthens its foreign exchange reserves.

Why has external debt (and especially short-term debt) been increasing with foreign reserves accumulation in China, South Korea and Taiwan? At the same time countries' trade balance has been on surplus, so countries have not needed short-term debt to cover imports. In fact, the volume of international trade does not seem to have any relationship to the level of short-term indebtedness (for example Rodrik & Velasco, 1999 and Broner & Lorenzoni & Schmukler, 2004), but simply is a case of optimizing costs. Even though short-term borrowing increases countries' exposure to liquidity crisis, it is preferred due to the fact that investors require a high term premium for holding long-term debt, making short-term borrowing much cheaper. Empirical work by Broner et al. (2004) shows that the term premium (the relative cost of borrowing long term) is, on average, positive and increases significantly during crisis. That explains not only why countries tend to borrow short-term, but also why they rely so heavily on short-term debt during periods of financial turmoil. The more countries accumulate their foreign exchange reserves, less risky they are seen by outside world and more cheaply they are able to drawn foreign capital.

Intervention to prevent a rise in the exchange rate can accentuate financial imbalances in terms of capital flows as well. As mentioned above, increased bank lending could finance excessive investment in certain sectors such as property markets. Another possible channel is that expectations of future currency appreciation could attract large short-term capital inflows, pushing up equity prices (Mohanty & Turner, 2006).

In figure 28 and 29, I have presented foreign direct investment figures. In figure 28 I have computed the aggregate sum of foreign direct investment divided by national gross domestic product to give a sort of proxy of how large are the capital flows in and out of a country and how have they varied across the years. In China, total FDI/GDP –ratio was near 1% until it suddenly jumped up to over 6% in 1994 thereafter slowly descending, being a little over 3% in 2006. In Taiwan, foreign direct investment flows have been drastically more volatile. Until 1998 they were rather low when compared to annual GDP,

started to increase but decreased again in 2002-2003, being around 4% in 2006. Korea has experienced the lowest foreign direct investment flows of the three. Total foreign direct investment to GDP –ratio has stayed around 1% for the whole 16 years, only increasing during the years after Asian crisis, but decreasing thereafter back to around 1.3% in 2006.

In figure 29 I then examine the net foreign direct investment flows (FDI towards a country minus FDI going abroad). When net FDI flow is positive, there is more direct investment coming into a country than flowing away. Net FDI is measured in millions of U.S. dollars.

In Taiwan, net FDI has been negative for the whole 16 years. The deficit was about 5 billion U.S. dollars during 2003-2005. In 2006 it was however only slightly below zero. Asian crisis seem to have had only a small negative impact on FDI flows towards Taiwan. FDI flows have apparently been very volatile in South Korea too. Net FDI flow was negative in Korea until the Asian crisis. Thereafter it ameliorated above zero and was at best nearly 6 billion U.S. dollars in surplus by 1999. The surplus deteriorated however thereafter, and slumped below zero again in 2006. Only in China has the net FDI flow kept an increasing trend. It was below zero until 1994 thereafter growing almost year by year, being about 55 million U.S. dollars in surplus by 2006. Figures for China can not be fully comparable with those of Korea and Taiwan, because of the more restricted capital flow possibilities, especially out of the country.

All in all, FDI flows do not seem to have a strong impact on growing foreign exchange reserves, or the other way around either. The only gathering conclusion that I could draw from these two pictures is that at least FDI flows have become more volatile in the 21st century for all of the three countries. This could then be a reason to acquire more stabilizing foreign exchange on central banks' balance sheets. This is in fact one statistically significant explanation in the multiple regression analysis presented below when taking into account the whole period (1990-2006) but looses its explanatory strength when only looking at years after Asian crisis (see chapter 4.3). Next I am finally turning to the second part of my empirical analysis; the multiple regression.

4.3 Regression analysis

At the end of this fourth chapter I present results obtained through multiple regression models that I performed for China, Taiwan and South Korea. My aim was to assess whether those classic explanatory variables presented in 3.2.1 still hold, or have the effects changed when examining the fast accumulation of foreign exchange reserves these three countries have carried out especially after the Asian crisis in 1997. Results are being presented in table 6, Annex 3.

4.3.1 Description of the data and variables to be estimated

Data sample comprises observations of China, Taiwan and South Korea between 1990 and 2006, sample size being 50 observations. Through the results I try to assess whether these three emerging Asian economies have similar causes for or consequences of (depends a lot of way of thinking) accumulating large foreign exchange reserves, and have the reasons substantially changed in the 21st century. Model to be estimated is of the form:

Equation 12: multiple regression model

$$Y_{i,t} = \beta_0 + \delta_i + \theta_t + \gamma + \sum_{k=1}^{K} \beta_k x_{k,i,t} + e_{i,t}$$

Where Y is the dependent variable, β_o is the constant, δ the country effect, θ the year effect, and γ the Asian crisis effect. x contains the explanatory variables, i = CHI, KOR, TWN being the countries, k = 1,…K the regressors and t = 1990,…,2006 the periods.

As variables, I have gathered numerous possible explanatory variables from existing literature. The dependant variable Y being FER/GDP –ratio, reflecting the relative size of countries' foreign exchange reserves. It is identical to that Aizenman and Lee used in their working paper I am presenting later in chapter 5 (Aizenman & Lee, 2005). This ratio I am then aiming to model with different variables, taking into account both mercantilist and classic views.

Size of the economy is being measured here with *GDP per capita* (in logarithms). It should have a positive effect on the dependent variable, although the inverse relationship was observed too (Lane & Burke, 2001) for developing countries. *Foreign trade/GDP* reflects countries openness to foreign trade, measured as imports and exports combined divided by country's gross domestic product. Openness to foreign trade should have a strong positive correlation with acquiring reserves (IMF, 2003; Gosselin & Parent, 2005; Lane & Burke, 2001). Also greater financial openness is associated with higher crisis vulnerability and thus influence positively with the demand for reserves. To measure that, I use debt-based indicators and the M2/GDP –ratio; *Total external debt, short-term debt/GDP* and *M2/GDP.*

As a proxy for exchange rate flexibility, I use the 5-year average standard deviation of foreign exchange rates (against the U.S. dollar). Some studies have simply used a dummy for different exchange rate regimes, but because of the fear of floating (Calvo & Reinhart, 2000) I use the actual measure of *exchange rate volatility.* This classic explanatory variable should have a negative impact on reserve accumulation, because when exchange rates are more flexible, monetary authorities no longer need a large stockpile of reserves to manage exchange rates.

Alongside with these classic explanatory variables I used others to better estimate the reasons for reserve hoarding. Other variables include: *current account balance* and *real exchange rate*, which would reveal the possible relationship argued by the mercantilist view (see also chapter 5.2.3) that reserves are being acquired in order to affect real exchange rates and terms of trade. Theory would then suggest that the relationship between real exchange rates and FER/GDP –ratio would be negative; an increase in real exchange rate implies lower terms of trade, which in turn would increase exports and increase thus the current account balance (surplus).

I did further add *government expenditure* and *domestic credit* as variables in the model, which in turn expose the possible range of action large reserves can have in the economy. While monetary authority is using excess currency to buy foreign exchange, it could imply

that it crowds out public expenditure in domestic economy at least to some extent. However, no such effect could be detected from the data, and government expenditure was excluded from the final analysis. Other consequence of reserves accumulation is the expanding banking sector, which could be approximated with the amount of domestic credit. Reasoning behind it being that while central bank is issuing large amount of government bonds to banking sector when sterilizing foreign exchange purchases, it increases commercial banks' reserves and allows them to issue more loans to the public. Measure of domestic credit should therefore have a positive relationship with foreign exchange reserves accumulation. Last explanatory variable to be added is *FDI volatility* which I am here using as a proxy for capital market insecurity.

I conducted a pooled time series – cross section multiple regression with E-Views program, with dummies for countries as well as for years. I added a dummy variable for the Asian crisis, *dummy crisis,* since while the Asian crisis in 1997 affected strongly Korea and to some extent Taiwan, China stayed rather intact. This way, overall correlations are not affected by jumps in economic indicators due to the strong negative shock. Crisis dummy got the value 1 for Korea and Taiwan during 1998-2006.

I first ran a model for all years 1990-2006 (model A). I did the same for periods before crisis 1990-1997 (model B) and post crisis, 1998-2006 (model C) separately. Results of the coefficients and t-statistics are shown in table 6, Annex 3. As can be seen straight ahead, the same variables are not simultaneously significant in models B and C. As for significance levels I have used three stars to denote the statistically significant relationship at the 0.01 level of significance and one star for that of 0.10 level of significance. Figures 30 to 32 are drawn using equation 12 and coefficients defined in models A to C. Predictions of these three models as well as the actual value of the FER/GDP –ratio for China, Korea, and Taiwan during 1990-2006 are depicted in the same graph for each country separately. I am next going through the results I derived from the models.

4.3.2 Obtained results

Model A seems to be able to predict rather accurately the growth rate of foreign exchange reserves to GDP –ratio for all of the three countries (see also figures 30-32). It overestimates the value of the ratio for Korea in 2006, but for China and Taiwan the prediction in fact lags behind. Statistically most significant explanatory variables are current account balance and the ratio of short-term debt to GDP (significant at the 0.01 level of significance). They are both positively correlated with the accumulation of foreign exchange reserves. Also exchange rate volatility, FDI volatility, size of the economy, and the magnitude of domestic credit are all affecting positively the FER/GDP –ratio (0.10 level of significance). From these explanatory variables domestic credit may well be endogenous, as the more liquid an economy is the more it could borrow to its citizens. However, excluding domestic credit variable from the model does not remarkably alter the coefficients of the remaining variables or their signs, and thus I can not be certain that it could not be in fact exogenous. One could also imagine that while domestic credit markets are expanding, the central bank could therefore prepare itself with more liquid assets.

From the figures 30-32 as well as from table 6 I can conclude that the same reasons that applied for foreign exchange accumulation before Asian crisis are not relevant afterwards. This implies that motives for acquiring more foreign exchange have indeed been altered during the past 15 years.

Model B states that prior Asian crisis the most significant reason (at the 0.10 level of significance) for acquiring large foreign exchange reserves was the exchange rate volatility. The model implied that during 1990-1997, the more the exchange rate was under the control of the central bank, the more it needed foreign exchange and vice versa. This strong statistical significance is clearly behind the underestimation of model B regarding years 1998-2006 for Korea (figure 31). Won was let to float freely in the aftermath of the Asian crisis in December 1997. Quite significant were also the size of the economy with a negative impact on FER/GDP –ratio (that is a smaller country needs more foreign exchange reserves than a big one) and M2/GDP –ratio. However their p- values were slightly over 0.1. Larger the money supply, the more reserves are needed. One could

of course think of the growth of M2 monetary aggregate as the effect, rather than the cause of FER accumulation. The negative impact of GDP per capita was already discussed in chapter 4.2.2 where I detected a pattern of a substantial GDP per capita decrease following by a stronger foreign exchange reserve accumulation (see also figures 18-20).

Results from model C however do not coincide with those just derived above. Statistically significant is now the openness of a country (foreign trade to GDP -ratio). Curiously, it has a negative coefficient implying that a more closed economy would acquire more foreign exchange. As figures 15-17 in fact show, after 1997 there has been decreases in foreign trade to GDP –ratio with all of the three countries especially after year 2000, the overall trend being however increasing. This could be taken as a sign of the foreign trade volatility increasing and thus countries need to acquire more stabilizing foreign exchange reserves.

Domestic credit is significant as an explanatory variable, but the sign is reversed from model A. Larger foreign exchange reserves denote now a decrease in domestic credit. Alternatively thinking, the less there is domestic credit (and thus domestic demand) the more central bank needs to acquire FER to keep exchange rates as such as to increase exports and economic growth. As could already be noted from figure 27 (see chapter 4.2.2 for discussion), development of domestic credit lending does not seem to have a clear pattern with foreign exchange reserve accumulation. That is why it has a positive impact on accumulation in model A, but is affecting on the contrary in model C.

Model C further implies that the more short-term debt a country has more it needs to accumulate foreign exchange. Same positive relationship was also statistically significant in model A, which makes short-term debt to GDP –ratio one of the rare estimators from recent studies that actually holds true for China, Korea, and Taiwan also after the Asian crisis. This despite to the fact that the structure of external debt is different and has evolved differently between the three countries.

To conclude, motives have in fact changed when crossing the new millennium in foreign exchange reserve accumulation. Before Asian crisis the strongest explanatory variable was the exchange rate volatility. It had a negative impact on reserve accumulation as was derived already in the era of Bretton Woods; more control meant larger foreign exchange reserves. However when examining years after 1997, the same variable still plays a part in explaining higher demand for foreign exchange only now the sign has reversed and is positive. A freely floating exchange rate increases foreign exchange volatility and it may cause problems especially among emerging economies. By lacking credibility and strength of financial markets, it makes them face bigger shocks and thus acquire more stabilizing foreign exchange (Calvo & Reinhardt, 2000). This is presumably the reason behind my result of positive relationship between exchange rate volatility and FER accumulation.

As is being discussed in a paper by Funke and Gronwald (2008), running intermediate exchange rate regimes like China is doing at present, is very difficult for countries with open capital markets. Speculative pressures will sooner or later challenge the credibility of intermediate regimes. Change in Chinese policy usually takes place through a series of small steps, and to protect the gradual appreciation RMB is now facing large foreign exchange reserves are needed to back the credibility of the monetary authority. Little by little China is moving towards more open capital markets, and by then it is forced to let go of the managed exchange rate regime.

Getting through the results of the multiple regression analysis and having a picture of motives why countries are accumulating ceaselessly larger foreign exchange reserves, I present next the theory behind costs large foreign exchange reserves are causing to a country, as well as modelling optimal level of reserves.

5. Calculating the welfare costs of FER

In this fifth chapter I am going through costs large foreign exchange reserves have on domestic economy and I start by listing welfare costs of excess reserves stated in the literature. I am then going through some of the most interesting working papers more thoroughly; introducing theories, calculations and conclusions, finally applying them to my case countries to see how results are changed in the light of updated data (2004-2007).

5.1 Costs of excess accumulation

First to the costs: Can we actually say that there should be a threshold level upon which a country should not accumulate its foreign exchange reserves in order to maintain profitability? Is more always better or is there a limit to gains from FER? The marginal benefit of accumulating more reserves is sure to decline at some point[20] (see Green & Torgerson, 2007). As the basic economic doctrine states we must match marginal returns with marginal costs in order to maximize welfare. Reserves are an expensive insurance mechanism with costs coming form many different sources which are furthermore often difficult to quantify.

Sterilization costs occur when monetary authority tries to offset the inflationary monetary impact FER accumulation brings by issuing for example domestic bonds. There are two types of sterilization costs that merit concern, namely the direct fiscal cost to monetary authorities and the indirect systemic cost of preventing current account adjustment, while the direct cost being the most commonly considered (Green & Torgerson, 2007). Fiscal cost represents the difference between the yield of international reserves and what it pays for domestic debt issued to sterilize reserves. If domestic interest rate is substantially low (as not so long ago in Japan) fiscal cost may well even be negative. However, poor data especially on the full extent and composition of sterilization make fiscal costs difficult to

[20] For a well-behaved distribution of events that require use of reserves, events large enough to require the marginal reserve dollar occur less frequently as total reserves increase. By boosting confidence, additional reserves also shift the whole distribution to the left, making their use even less likely.

measure[21]. Anecdotal evidence indicates that substantial sterilization has been taking place in East Asia over the past few years (Mohanty & Turner, 2005) and while yields have been fairly low for U.S. Treasury bills, direct fiscal costs must be considered.

Indirect systemic costs come from the fact that through sterilized intervention monetary authorities can affect the real exchange rate (see also chapter 2.3) and prevent domestic currency from appreciating. The practice of obstructing real exchange rate appreciation adjustments can be harmful by distorting price signals for resource allocations (Green & Torgerson, 2007). These actions can lead to overinvestment in tradable sector at the expense of non-tradable sector and cause speculative capital flows and asset price bubbles, although these capital flows usually tend to lower interest rates and therefore have a positive impact on direct fiscal costs.

Opportunity costs derive from the idea that the resources used to purchase international reserves could have been used in a number of alternative ways. A government could pay down its sovereign short term external debt, since the interest cost of a given amount of short-term external debt surely exceeds the earnings on an equivalent sum of reserves. Paying down sovereign short-term external debt would then have a similar effect in reducing vulnerability by the Greenspan-Guidotti rule (introduced in chapter 3.1) with a lower net cost.

Government could also spend reserve money in different investment projects, with the obvious natural constraint that reserves can not be converted back into local currency if authorities wish to avoid a lowering impact on the exchange rate (Green & Torgerson, 2007). Returns from public investment may be significantly higher than current earnings on reserves as long as they are efficiently allocated. More efficiency can be acquired by allowing the private sector to determine the best allocation for foreign reserves, as have a

[21] Sterilization is sometimes approximated over a short time horizon by the difference between changes in net foreign assets and net domestic assets, ($\Delta M = \Delta NFA + \Delta NDA$), since sterilization aims to keep the money supply unchanged. However, even in absence of official interventions, monetary base will not stay constant in a fast growing economy with a developing financial sector and active monetary policy. Money supply growth to match natural increase in money demand will introduce too much noise to reliably identify even large-scale sterilization by this method.

number of central banks already done by letting investing management corporations take care of some of the reserves. Profit can be earned and opportunity costs lowered by moving the domination of low-yield foreign government bonds away from the portfolio.

Central bank balance sheet risk: Foreign exchange reserves, just like any other foreign currency asset can lose their value in local terms when the exchange rate appreciates. In cases where foreign assets form a large share of central bank's balance sheet, the institution faces the risk of significant losses (Green & Torgerson, 2007). While turning undercapitalized, central bank can jeopardize its credibility and ability to target price stability, to act as a lender of last resort, or to maintain a domestic payments system. Since balance sheet losses are rather more potential than current cost, central banks should consider the future effects possible appreciation may bring along.

Other costs: Reserve accumulation may render a false sense of security, delaying necessary reforms in a so called *too big to fail* –syndrome. Large fiscal deficits may crowd out private sector investment or create debt overhang problems. Large FER accumulation in a number of countries has been associated with easier financing conditions (see Mohanty & Turner, 2006 for details) and easy profits from large holdings of domestic treasury securities could alter the behaviour of banks; weaken pressures to become more efficient and slow down the development of credit culture. While banks with such liquid assets feel better placed to expand credit, restraining influence of sterilized intervention on monetary growth could prove temporary (Mohanty & Turner, 2006). While backed by strong central bank, banks can issue loans more recklessly, and the share of non-performing loans might pose new problems in the future. Additionally, large-scale issuance of sterilization-related debts might also hamper the development of private bond market, as large supply of risk-free government and central bank paper crowds out private sector issuance (Mohanty & Turner, 2006).

Finally, reserve accumulation adds another variable to the sometimes difficult formulation of monetary policy under flexible exchange rates (Green & Torgerson, 2007). The difficulty of coordinating monetary policy with intervention and the *risk of being*

distracted from monetary goals by exchange rate goals can result in undesirable volatility in macroeconomic variables.

5.2 Theories and calculations

Next I am presenting in more details four recently published working papers, where writer(s) attempt to compute quantitative costs foreign exchange reserves accumulation is presently bringing. While costs are calculated high in all cases, there appears to be more of a consensus that countries are getting their moneys' worth. I then finish this fifth chapter by comparing current situations in China, South Korea and Taiwan, along with my own calculations, with these theories and results presented below.

5.2.1 Social cost of foreign exchange reserves

Dani Rodrik wrote a working paper about social cost of foreign reserves in 2006. I present his calculations next. Rather than the fiscal cost (spread between the interest on domestic government bonds and the yield on reserves expressed in a common currency), Rodrik used the following way of thinking: Consider a country living by the Greenspan-Guidotti rule; so all external short-term debt should be covered by foreign exchange reserves. Now a domestic firm takes a short-term loan from abroad of $1 million. Central bank now has to raise its reserves for the same amount. The central bank purchases foreign currency in domestic financial markets to invest in U.S. government or other foreign short-term securities and sterilizes the effects of its intervention on the money supply by selling domestic government bonds to private sector. When all these transactions are completed, domestic private sectors ends up holding $1 million of domestic government bonds balancing its foreign liability of $1 million, while the central bank has $1 million more in foreign assets and $1 million less in domestic government bonds.

The home economy ends up with no net resource transfer from abroad and aggregating domestic private and public balance sheets, the net effect is that the economy has borrowed short term abroad (at the domestic private sector's cost of foreign borrowing) and has invested the proceeds in short-term foreign assets. This brings out the negative spread which is used in calculating social costs. Rodrik also computed only the cost of holding reserves in excess of the amount that is required to satisfy the three months of imports rule.

As estimates of the spread between private foreign borrowing costs and yields on reserves assets Rodrik used U.S. Treasury securities and other short-term assets as an estimate of the yield, but in the case of private foreign borrowing costs he admitted to face a problem. Most short-term private borrowing takes the form of commercial bank lending at rates which are not publicly available. Some indirect guidance can be obtained through EMBI[22] spreads. Finally Rodrik came into conclusion and presented three set of calculations, based on negative spread levels of 3 percentage points, 5 percentage points and 7 percentage points. With the high levels of foreign exchange reserves in developing countries in the 21st century, and using the mid-point of his range of spreads (5 percentage points), the cost of excess reserves stood in 2004 at close to 1 percent (0.9%) of developing countries' GDP (with 3 %-point spread result was 0.5% of GDP and with 7%-point spread close to 1.3% of GDP).

Rodrik counted in another paper in 1999 with his co-author Andres Velasco (Rodrik & Velasco, 1999) that a country obeying the Greenspan-Guidotti rule of holding reserves equal to at least its short-term debt reduces the annual probability of experiencing sharp reversal in capital flows by 10 percentage points on average. While further Hutchison and Noy (2002) counted, the output cost of a financial crisis is on average of the order of 10 percentage points of GDP, in expected value terms the benefits of the Greenspan-Guidotti rule amount to about 1 percentage point of GDP (0,10 x 0,10). In other words, risk-averse governments ought to be willing to invest more than 1 percentage points of GDP in order to acquire enough liquidity.

[22] Emerging Markets Bond Index tracks total returns for traded external debt instruments in the emerging markets

5.2.2 A fiscal price tag for international reserves

David Hauner wrote a paper in 2005 examining the (quasi-)fiscal effects of holding international reserves. He stated that reserves have a fiscal opportunity cost because they could alternatively be used to finance public expenditure or to pay down external debt and reduce the interest bill. In addition to that, they also create a benefit or loss through the financial return on reserves, a lower government interest bill if reserves and interest rate spreads are negatively correlated, and often a sterilization cost. He proposes a conceptual framework for the quantification of the net (opportunity) cost of a country's reserves.

The fiscal opportunity cost consists of (a) the forgone return from alternative uses, minus (b) the financial return on the reserve assets, minus (c) the savings from a lower interest bill if higher reserves are associated with lower spreads, plus (d) the present cost of past sterilizations. Formally, it can be noted as:

$$C_t(R_t) = \left(\max\left\{r_t^e, r_t^k\right\} - r_t^s - d_t\right)R_t - \varphi_t D_t$$

Where C_t denotes opportunity costs of holding international reserves, R_t in period t. The first term represents aforementioned (a) and (b), where r^e is the average interest rate on the country's external debt, r^k is the social return on public capital formation, r^s is the foreign currency return on reserve assets, and d_t is the weighted depreciation rate of the domestic currency against reserve currencies. The second term represents (c), where $\varphi_t = f(R_t, X_t)$ is the reduction in the yield spread on the country's privately held external debt D_t, 'bought' by holding reserves R_t and X_t is a vector of the other explanatory variables. Due to data constraints, the present cost of past sterilizations cannot be calculated, and is therefore being excluded from the cost equation.

For the estimation of the incremental yield spread saving φ_t from holding reserves, Hauner continues by modelling the actual yield spread φ^a as a linear function of reserves and a vector of other variables, X_t:

$$\varphi_t^a = \alpha + \beta R_t + \gamma X_t$$

Therefore, $\varphi_t = \varphi_t^0 - \varphi_t^a = (\alpha + \beta \cdot 0 + \gamma X_t) - (\alpha + \beta R_t + \gamma X_t) = -\beta R_t$

and the first equation can be rewritten as $C_t(R_t) = (\max\{r_t^e, r_t^k\} - r_t^s - d_t - \beta D_t)R_t$

Hauner used data from IMF International Financial Statistics and estimated the fiscal cost of reserves in the world's 100 largest economies (except the U.S., the reserve "centre") over the period 1990-2004. As a result, he accounted that while reserves were profitable before the 21st century, after 2002 all country groups have been loosing money on their reserves.

Estimated opportunity cost was about 0.5-0.6% of GDP in Emerging Europe, Latin America, and Middle East/Central Asia, and about 0.2-0.3% of GDP in Asia Pacific and the advanced economies excluding Asia. External debt repayment seemed to be a more attractive option than public investment in most cases, exception being Sub-Saharan Africa, where public investment would yield a higher profit than debt repayment.

The estimated benefit from international reserves was substantial over the most of the 1990's, but declined significantly thereafter. Foreign currency return on the reserve assets peaked in 2000 at 0.9% of GDP in Asia Pacific, 0.8% in Middle East/Central Asia, 0.7% in Emerging Europe and the advanced economies excluding Asia. However, since then the decline in industrial country interest rates has brought down the estimated median return to only 0.2-0.3% of GDP in most regions, or even lower in some. The estimated revaluation gain (world median) was positive for all years during 1990-2002, peaking at 1.9% of GDP in 1999. The decline in U.S. dollar against many currencies since then has swung the revaluation gains into losses for many countries. Estimated savings from a lower interest rate spread on external debt appear to be relatively small in most countries, albeit in Emerging Europe and Middle East/Central Asia that combine substantial private sector debt, large international reserves, and in some cases high spread/reserves elasticity, estimated savings have increased to about 0.3-0.6% of GDP in recent years.

In sum, the estimated net (opportunity) cost of international reserves suggests that most countries were making money on their reserves during 1990-2001. However, in 2004, all country groups seem to have lost money on their reserves, with the medians of the estimated net costs ranging from -0.4 to 0.2% of GDP in Asia Pacific, over 0.0-0.2% in Middle East/Central Asia, and 0.0-0.6% in Latin America to 0.2-0.8% in the advanced economies excluding Asia, Emerging Europe and Sub-Saharan Africa.

Hauner admits that broad country coverage, as in his paper, comes at a cost: detail on individual country cases may get lost. Therefore, he states, case studies of selected countries could be useful extensions of the global examination he conducted.

5.2.3 Precautionary vs. mercantilist views

Model developed by Joshua Aizenman and Jaewoo Lee in 2005 was presented in their IMF working paper *International Reserves: Precautionary vs. Mercantilist Views, Theory and Evidence.* The model provides a welfare evaluation of the costs and benefits of hoarding reserves and the optimal size of the precautionary demand. The view that countries are accumulating their international reserves for precautionary motives faces a well-known contender in a modern incarnation of mercantilism: international reserve accumulations triggered by concerns about export competitiveness. The precautionary approach links reserve accumulation directly to exposure to sudden stops, capital flight, and volatility whereas the mercantilist approach views reserves accumulation as a residual of an industrial policy, a policy that may impose negative externalities on other trading partners.

Aizenman and Lee constructed first a regression model, adding several new controls to past regressions. The mercantilist view focuses to prevent or mitigate appreciation, with the ultimate goal of increasing export growth. Hence, they expected that hoarding of reserves should be associated with higher export growth rates, and with a depreciated real exchange rate relative to the fundamental PPP real exchange rate. They constructed a three-year moving average of the growth rate of real exports, lagged two years in the

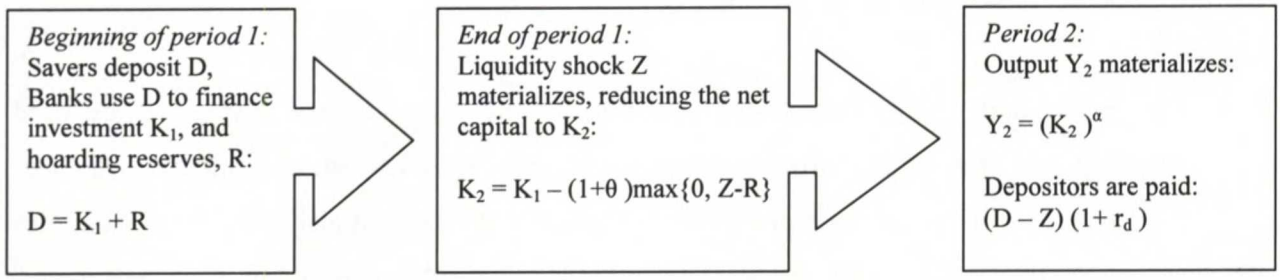
regression. The PPP real exchange rate is defined as the fitted value from the regression of national price level on the per worker income relative to the U.S. for nearly 150 countries and deviations from the fundamental PPP value are measured by the residuals of their regression. If a country whose price level is above the level implied by its relative income tends to accumulate international reserves as an effort to mitigate appreciation of its currency, the coefficient will be positive in the regression.

As the second set of controls they focused on the precautionary motives. They used dummy variables for the two important crises, the 1994 Mexican and the 1997-98 East-Asian crises. In one of the regressions Aizenman and Lee used also continental dummies for each crisis and in addition, they controlled for log of population, log of percent import share, exchange rate volatility and log for per capita income.

The reserves/GDP ratio as dependent variable, results from the regression are as follows: mercantilist views do have a positive correlation with accumulating international reserves, although their economic importance in accounting for the observed hoarding is practically close to zero. Trade openness is the most important factor in reserve accumulation; also the crises-variable plays a big role. The regional crisis dummy variables show that while the Mexican crisis led also other Latin American countries to increase their reserves, it did not affect countries' reserves in say, East Asia. Similar case was with the East Asian crisis a few years later.

Overall, the empirical results described above are in line with the precautionary motive. Yet, sceptical views point out that the sheer magnitude of reserves accumulated by East Asian countries seems excessive once attention is paid to the opportunity costs of reserves. In order to deal with these concerns, Aizenman and Lee provided a simple model characterizing and quantifying the welfare gains attributed to hoarding reserves in the presence of exposure to external liquidity shocks. The model extends literature dealing with the demand for bank reserves in a closed economy to the important, yet less studied open-economy context.

Focus on developing countries; they assume that all financial intermediation is done by banks. Investment in a long-term project should be undertaken prior to the realization of liquidity shocks. Hence, the liquidity shock may force costly liquidation of earlier investments, reducing second period output. Time line is presented below:



Source: Aizenman and Lee (2005)

Assuming a Cobb-Douglas production function, second period output is:

$$Y_2 = \left[K_1 - (1+\theta)\max\{Z - R, 0\}\right]^{\alpha} \quad \text{where } 0 \le \theta < 1 \text{ and } \alpha < 1.$$

Recalling that K_1 = D-R, the net capital after liquidation is:

$$K_2 = \begin{cases} D - R - (1+\theta)(Z-R) = D - Z - \theta(Z-R) \Leftrightarrow Z > R \\ D - R \Leftrightarrow Z \le R \end{cases}$$

It is convenient to normalize the liquidity shock by the level of deposits, denoting the normalized shock by z:

$Z = zD$; $0 \le z < \tau \le 1$, and density $f(z)$

Depositors are entitled to a real return of r_d on the loan that remains deposited for the duration of the investment. Assuming agents' subjective discount rate is ρ, competitive intermediation implies $\rho = r_d$. Net reserves held until period 2 are assumed to yield a return of r_f. Aizenman and Lee denote the marginal liquidity shock associated with liquidation by $z^* = R/D$. Expected second period surplus (i.e. net income after paying depositors) is the sum of expected output, plus the income associated with reserves net of liquidation, minus the repayment to depositors who get a return of ρ on the net deposit position, $D-Z$. Applying $Z = zD$ above and the definition of z^* we can write the expected surplus as:

$$E[\Pi] = D^{\alpha}\left[\int_0^{z^*}(1-z^*)^{\alpha} f(z)dz + \int_{z^*}^{\tau}(1-z-\theta[z-z^*])^{\alpha} f(z)dz\right] +$$

$$D\left[(1+r_f)\int_0^{z^*}(z^*-z)f(z)dz - (1+\rho)\int_0^{\tau}(1-z)f(z)dz\right]$$

The first order condition determining the optimal demand for international reserves is thus:

$$0 = D^{\alpha-1}\left[-\alpha(1-z^*)^{\alpha-1}\int_0^{z^*} f(z)dz + \theta\int_{z^*}^{\tau}\alpha(1-z-\theta[z-z^*])^{\alpha-1} f(z)dz\right] + (1+r_f)\int_0^{z^*} f(z)dz$$

This condition is equivalent to $[MP_K - (1+ r_f)] \cdot \Pr[Z<R] = \theta E[MP_K \mid Z>R]$.

Where MP_K is the marginal productivity of capital and Pr [Z<R] is the probability that the liquidity shock is below the level of reserves. The expected opportunity cost of holding reserves is equalized to the expected precautionary benefit of holding reserves. Hoarding an extra dollar reserves reduces the initial capital by one dollar, reducing output for liquidity shocks below z^*, shifting the output downwards. Extra dollar reserves implies, however, lower deadweight loss associated with liquidation, thereby shifting the output upwards for $z > z^*$.The expected net gain in production from holding reserves corresponds to the difference between these two effects. Optimal reserves, which satisfy equation above, maximize the overall expected gain.

In the absence of uncertainty, the optimal level of deposits (D_0^*), and the resultant surplus (Π_0) is:

$$D_0^* = \left[\frac{\alpha}{1+\rho}\right]^{\frac{1}{(1-\alpha)}}; \qquad \Pi_0 = (1+\rho)D_0^*\frac{1-\alpha}{\alpha}$$

Further suppose that the liquidity shocks are either zero or z_o, with probability half each, and that $\rho = r_f$. If reserves are set to zero and deposits at D_0^*, the first order approximation of the expected surplus can be reduced to:

$$E[\Pi]_{R=0} \cong \Pi_0 - \theta \frac{z_0(1+\rho)D_0^*}{2}$$

Liquidity shocks have a first-order adverse effect on expected surplus. In the absence of the insurance provided by the reserves, liquidation induces a deadweight loss equal to the adjustment cost, θ, times the expected liquidation. Perfect stabilization can be achieved by hoarding reserves equal to the liquidity shock, $R=z_0D_0^*$, adjusting deposits to $D = (1+z_0)D_0^*$ thereby setting the stock of capital at $K_1 = D_0^*$. If the liquidation shock materializes, R would provide the needed liquidity, preventing costly output adjustment. If the shock is nil, there would be no need to use R. The assumption that $\rho = r_f$ implies that the cost of this insurance is in fact zero.

This example suggests that liquidity shocks have first-order welfare effects in the absence of reserves, and that hoarding reserves can reduce the cost of liquidity shocks from first – to second-order magnitude. Aizenman and Lee further simulated the model to confirm the results. Increase in D is needed to mitigate the costly drop in output induced by reserves accumulation and is needed to keep the planned capital at the optimal level. Whit this model Aizenman and Lee concluded that precautionary demand is consistent with high level of reserves.

5.2.4 Trying to estimate optimal foreign exchange reserves

Pablo Garcia and Claudio Soto (2004) determined in their working paper "*Large Hoardings of International Reserves: Are they worth it?*" alongside with calculating opportunity costs the optimal level of international foreign exchange reserves. Their model follows closely the cost-benefit analysis presented by Avi Ben Bassat and Daniel Gottlieb in (Ben Bassat & Gottlieb, 1992).

In the model, central bank has to decide a proper level of reserves by minimizing an expected loss function that considers both the effects of reserve accumulation in terms of

reducing the expected cost of crisis, and the opportunity cost of reserves. The loss function takes the following form:

$$\Delta_t = p_t C_t + (1 - p_t)\rho_t R_t$$

Where p_t is the probability of crisis which depends on the reserves to short-term debt ratio, C_t is the cost of crisis, R_t is the level of reserves and ρ_t is the unit cots of reserves.

The central bank decides period by period the optimal amount of reserves by minimizing the loss function subject to:

$$K_t - W_t + R_t = D_t,$$

where K_t is the capital stock of the economy, W_t is total wealth, and $D_t = S_t + LTD_t$ is the total debt of the country composed by short-term and long term debt.

An important assumption by Garcia and Soto is that any change in reserves is financed with long term borrowing and short-term debt is predetermined. It is important in order to have an interior solution for the optimal amount of reserves. Alternatively, we could suppose that reserves are completely financed by short-term debt. Any change in reserves conveys a one-to-one change in short-term debt, and the ratio between them is never modified. This implies that the authority can never affect the probability of crisis by adjusting reserves and thus the optimal amount of reserves would tend to be zero given the costs of carrying reserves.

Garcia and Soto assume that reserves not only affect the probability of crisis but also the costs. Depending on how reserves are utilized, and in cases where a crisis has its origins in a liquidity shock, larger amounts of international reserves could imply that countries avoid costly liquidation of assets. This, in turn, would reduce the impact of the shock on domestic output. The cost of a crisis – as a fraction of GDP – is a function, amongst other variables, of the reserves to short-term debt ratio:

$$\frac{C_t}{Y_t} = C\left(\frac{R_t}{S_t}, \cdots\right)$$

The first order condition for the problem of the central bank is given by the following expression:

$$p_{R,t}C_t + p_t \frac{\partial C_t}{\partial R_t} + (1-p_t)\rho_t - p_{R,t}\rho_t R_t = 0$$

,where the partial derivative of the crisis probability with respect to R is given by

$$p_{R,t} = (1-p_t)p_t\left(\beta_0 \frac{1}{S_t} + \beta_1 \frac{1}{Y_t}\right).$$[23]

Garcia and Soto have assumed that opportunity cost of reserves is independent from the reserves to short-term debt ratio. In theory, this opportunity cost corresponds to the difference between marginal productivity of capital in the economy and the yield on reserves – which is typically lower than productivity of capital (Garcia & Soto, 2004). In the working paper's empirical approach, writers take as a proxy for this opportunity cost sovereign spread of each country in their sample. Now combining the previous expressions, one obtains the following non-linear equation for level of reserves R_t:

$$0 = (1-p_t)p_t\left(\beta_0\left(\frac{S_t}{Y_t}\right)^{-1} + \beta_1\right)\left(\frac{C_t}{Y_t} - \rho_t \frac{R_t}{Y_t}\right) + p_t\eta\left(\frac{S_t}{Y_t}\right)^{-1} + (1-p_t)p_t$$

,where $\eta = \frac{\partial C}{\partial (R_t / S_t)}$ corresponds to the change in the cost of a crisis associated with a change in the reserves to short-term debt ratio.

Garcia and Soto then computed optimal level of reserves for four Asian countries (Korea, China, Thailand and Malaysia) and for Chile. As a proxy for opportunity cost, they used sovereign spreads from EMBI global. As the crisis probability they used two of their benchmark estimates developed earlier in the working paper: one that utilizes Bank for International Settlements (BIS) data to construct reserves to short-term debt ratio, and one

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[23] The initial formula of crisis probability is being derived earlier in their paper and being of the form

$$p_t = \frac{\exp\left(\beta_0 \frac{R_t}{S_t} + \beta_1 \frac{D_t}{Y_t} + Z\gamma_t - \varepsilon_t\right)}{1 + \exp\left(\beta_0 \frac{R_t}{S_t} + \beta_1 \frac{D_t}{Y_t} + Z\gamma_t - \varepsilon_t\right)}$$

that utilizes World Bank (WB) data[24]. Finally they assume that $\eta = -0.0025$, as estimated by De Gregorio and Lee (2003) for the marginal effect of reserves to short-term debt ratio on the cost of crisis.

Table below represents the results (although I am only representing figures on China and Korea) of the estimates of optimal level of reserves for three possible crises cost: 5% of GDP, 10% of GDP and 15% of GDP. These figures correspond roughly to the cost of three different types of crisis according to IMF (1998) estimates: A currency crisis, a currency crash, and a banking crisis. Figures for Korea are only available from 2002 and 2003.

Table 3: Actual and optimal reserves

		Optimal Reserves (%of GDP)					
	Actual Reserves (%of GDP)	Crisis cost 5% of GDP		Crisis cost 10% of GDP		Crisis cost 15% of GDP	
		BIS	WB	BIS	WB	BIS	WB
China							
2000	15.9	4.45	6.63	6.58	10.48	7.87	12.86
2001	15.6	5.89	6.31	8.98	9.21	10.83	11.01
2002	18.3	6.88	8.74	9.67	17.52	11.35	22.96
2003	23.0	7.51	12.15	10.48	21.54	12.28	27.36
Korea							
2002	24.1	21.80	0.33	34.85	18.87	42.65	30.52
2003	25.5	37.06	17.14	52.08	38.53	60.98	51.86

Source: Garcia and Soto (2004)

According to BIS estimates, China's level of reserves is well above the optimal levels, even in the prospect of a severe financial crisis. If considered the World Bank estimates then China's reserves would be consistent with a cost of a crisis that ranges from mild to strong. As with Korea, if we consider the results based on the WB data, the amount of reserves held would roughly equal the optimal amount for a mild crisis. However, by all

[24] The main difference between the data on short-term debt from the BIS with respect to that of the World Bank is that the first comprises not only debt with maturity of up to one year but also amortizations due within one year.

other levels of crises as well as all the results based on BIS data, the amount of reserves held by South Korea is surely not above what would be optimal for the country. Even if the cost of crisis is low the amount held in 2003 would be justified. For mild and severe cost of crisis the optimal amount of reserves could be up to two-fold of what was actually being held.

These findings could have been altered a lot, though, after the unprecedented accumulation of reserves especially China has been responsible for over these few years after Garcia and Soto wrote their paper, which is one of the reasons I present my own calculations next.

5.3 Current situation in China, Korea and Taiwan

I am using the results of Hauner (2005) and Garcia & Soto (2004), to study what is the situation of foreign exchange reserves' levels in China, Korea and Taiwan at present.

David Hauner examined the net opportunity costs foreign exchange reserves bring to a country. He concluded that countries were making money on their reserves before 2002 but since then, costs have been larger than returns. Hauner concluded his study by stating that case studies of selected countries would be useful extensions on his global examination. His calculations stopped in 2003, albeit thereafter have the foreign exchange reserves been accumulating faster than ever and it would be interesting to see how opportunity costs have escalated.

I have combined results from Hauner (2005) and Garcia & Soto (2004) and compared both the expected costs of possible crisis and the prevailing costs of reserves to see how well reserves are protecting countries from economic disasters. Garcia and Soto calculated the optimal level of foreign exchange reserves using approximations of crisis probability, which in turn depended on level of reserves, amount of external debt and exchange rate regime to mention a few. Hauner calculated the opportunity cost of actual reserves taking

into account the development in country's external debt ratings, currency's depreciation rate against reserve currencies, yield on reserves and social return on public capital formation (≈ marginal product of capital). I have used these models to determine the actual cost of reserves China, Taiwan and South Korea have been paying for their reserves during 2004-2007. The models do actually fit fairly well with the motives behind foreign exchange demand derived from the multiple regression analysis in chapter 4.3.2. As it seems, foreign exchange reserves are being accumulated expressly to avoid costly currency crisis which make the modelling of optimal reserves presented first by Garcia and Soto roughly a realistic means.

In table 4 below I have first gathered in the left-side column the costs actual foreign exchange reserves bring to each of my case countries at present, and in the next three columns the expected costs of a possible currency crisis with these actual level of reserves. The equation to calculate the costs of reserves is taken from Hauner (2005) and to obtain the expected cost of crisis I am applying the model of crisis probability by Garcia and Soto (2004). Expected cost of a crisis is thus its probability times its cost[25].

Table 4: Costs of FER and expected costs of crisis (% of GDP)

	Cost of reserves , % of GDP	Expected cost of crisis, % of GDP		
		cost 5 %	cost 10 %	cost 15 %
	China			
2004	1.7458	0.0720	0.1441	0.2161
2005	1.7609	0.0721	0.1443	0.2164
2006	2.9063	0.0645	0.1291	0.1936
2007	4.6882	0.0376	0.0752	0.1127
	Korea			
2004	5.6479	0.1801	0.3601	0.5402
2005	1.3045	0.1985	0.3970	0.5955
2006	2.7809	0.2549	0.5097	0.7646
2007	0.7535	0.2624	0.5248	0.7871
	Taiwan			
2004	9.3933	0.1120	0.2240	0.3360
2005	0.7836	0.1260	0.2521	0.3781
2006	2.6821	0.1219	0.2439	0.3658
2007	2.8450	0.1211	0.2423	0.3634

Source: Author's calculations

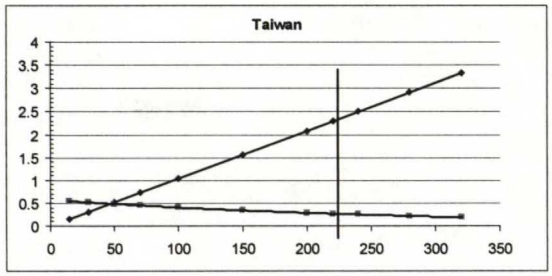
[25] Cost levels 5%, 10%, and 15% of GDP according to IMF estimates: a currency crisis, a currency crash, and a banking crisis. These figures were also used by Garcia and Soto (2004), see chapter 5.2.4

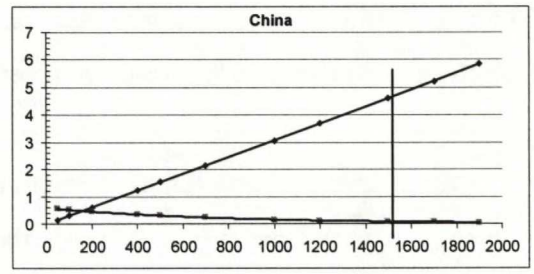
As can be noted from table 4 above, the only country of these three whose level of reserves is somewhere at its optimum is Korea. Korea's foreign exchange reserves cost the country in 2007 0.75% of its GDP, while the expected cost of a currency crash would be 0.525%, and that of a banking crisis as much as 0.787% of GDP. Thus, the level would seem rational to be gathered for precautionary motives. However in China and Taiwan, the fiscal costs of reserves like David Hauner modelled them are way over their expected costs of crisis. In China, cost of reserves is currently as high as 4.7% of GDP, which is immense regarding the expected cost of crisis which is even at its worst only 0.11% of GDP. It is due to the fact that the level of reserves is already so high that the probability of a financial crisis has almost vanished. On the other hand, the fiscal costs of reserves have been increasing annually since 2004, mainly because of the gradual but escalating appreciation of RMB against U.S. dollar which I am here considering as the only reserve currency, just to make some simplifications. Even the gains from lower external interest payments have not helped in reducing costs resulting from the reserves, albeit China has managed to increase its international sovereign rating three years in a row (2004-2006).

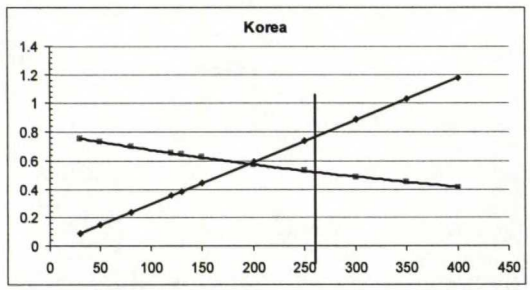
In Taiwan, the costs have varied strongly, to a large extent because of the changes in the foreign exchange rate. In 2004 NT dollar was appreciating, depreciating the following year, and then again appreciating in 2006-2007. Costs of reserves at present for Taiwan are 2.85% of GDP, while a banking crisis would "only" be expected to cost 0.36%.

Below I have calculated returns and costs of reserves for all of the three countries to have a clearer image where would more balanced levels of reserves situate. Curves for figures below are calculated by taking the situation of year 2007 as given, and only the level of reserves, *ceteris paribus,* is a changing variable. Cost of crisis is set to be 10% of GDP.

Returns and costs based on models by Hauner (2005) and Garcia & Soto (2004)







Source: Author's calculations

In the figures above, total amount of foreign exchange reserves is on the horizontal axes (in billion U.S. dollars) while the share of GDP (%) is on the vertical axes. Other things being equal and only altering the amount of foreign exchange on central banks' balance sheets, I came up with two curves; costs (upward sloping) and returns (downward sloping curve). Costs are being counted as they were in table 4, from the equation (Hauner, 2005):

$$C_t(R_t) = \left(\max\left\{r_t^e, r_t^k\right\} - r_t^s - d_t\right)R_t - \varphi_t D_t$$

Only now excluding the last term of possible savings from a lower interest on external debt, and putting t = 2007. Probability of a financial crisis comes equivalently from (Garcia & Soto, 2004)[26] with t = 2007:

$$p_t = \frac{\exp\left(\beta_0 \frac{R_t}{S_t} + \beta_1 \frac{D_t}{Y_t} + Z\gamma_t - \tau_t\right)}{1 + \exp\left(\beta_0 \frac{R_t}{S_t} + \beta_1 \frac{D_t}{Y_t} + Z\gamma_t - \tau_t\right)}$$

Arriving obviously at the same result as with table 4, these three figures show that only Korea is near its optimal level of reserves, or near to the point where marginal costs equal

[26] Definitions of coefficients and variables can be obtained in Garcia and Soto, 2004.

marginal benefits from the reserves. Benefits again defined as the expected cost of crisis that could be avoided due to larger reserves. Straight vertical lines in the three figures represent the size of the foreign exchange reserves at present.

Korea's optimal level of reserves in present situation would be about 190 billion dollars, that is to say the actual reserves have more than 70 billion dollars in excess. However all in all, Korea is losing only 0.25% of its GDP for holding on to those excessive reserves, while the figure for Taiwan and especially for China is immensely larger. In China at present it would be most reasonable to keep foreign exchange reserves of the size of 160 billion dollars, one tenth of what it actually is. Because of the excessive reserves, country is making a loss of more than 4.5% of GDP. With Taiwan, the situation is slightly better, optimal level being just over 40 billion, loss from actual reserves standing at 2.6% of GDP.

6. Conclusions

Foreign exchange has encountered a higher demand in emerging Asian economies in the 21st century than ever witnessed before and thus the motives for overall FER accumulation must have altered, especially after the Asian crisis that broke out in 1997. This strategy of acquiring continuously larger reserves can be immensely costly as could be detected from chapter 5. Further domestic currencies are appreciating against reserve currencies, the more it creates losses. And while reserves seem to be way over their fiscally optimal levels especially for China and Taiwan (chapter 5.3), other reasons must exist than just precautionary motives to avoid costly crisis.

From the multiple regression analysis I can derive that the most significant explanatory variables at present are exchange rate volatility, ratio of foreign trade to GDP, relative amount of short-term debt, and the amount of domestic credit. While moving towards freely floating exchange rates, they become more vulnerable to fluctuations especially in emerging Asian economies where a severe financial crisis occurred only a decade ago. Affecting exchange rates is also a means for Asian central banks to influence on the progress of economy's exports. This is in particular important if the emerging economy can not depend on its domestic demand.

Inflation as well as interest rates have been substantially low in these Asian economies which entails benefits from overall stability. One big part in acquiring such deep credibility comes from large and liquid reserves. While capital markets not yet fully open especially China and Taiwan are gradually taking steps towards more freely floating exchange rates. This requires large amount of liquid assets in order to avoid costly financial crisis. Backed by large liquid reserves, central banks do to a certain extent furnish a guarantee for individual agents as well. Large reserves are also a guarantee for national currency to not to be overvalued which in turn draws more capital into a country. This seeking of credibility and stability is surely the reason behind reserve accumulation today. Not just to avoid costly crisis but also to provide a more predictable future and thus to boost economic growth. This is perhaps also the answer for the problem that the fiscal

costs of accumulation have well exceeded the expected cost of financial crisis, especially in China and Taiwan. As returns from this strategy should also be included the economic growth provided for several years to come.

It is studied (Caballero & Krishnamurthy, 2007) that while central bank by intervening in international financial markets leaves the welfare of a rational individual agent slightly smaller, the average ex-post consumption utility increases by more. That is, central bank interventions leave the whole economy better off, although the deduction in question involved some restrictions.

Even in a sample size as small as three countries, there are profound differences in country's development and thus in fundamental reasons for acquiring large amount of foreign exchange. Albeit I could build a multiple regression model which fairly well predicts the accumulation at present, like former studies it can easily loose its explanatory power in the future. Recent FER accumulation could as well solely be a question of hoarding that is when one starts to accumulate others around simply follow. In Asia, where the status of emerging economy was enough to drag a country into the deep financial crisis ten years back one surely wants to secure itself from future crisis. Thus far, hoarding has paid off seeing that emerging Asia is experiencing a fast economic growth with fairly stable exchange rates, solid interest rates, low inflation, and blooming exports. All covered with extensive liquid assets like nowhere else in the world.

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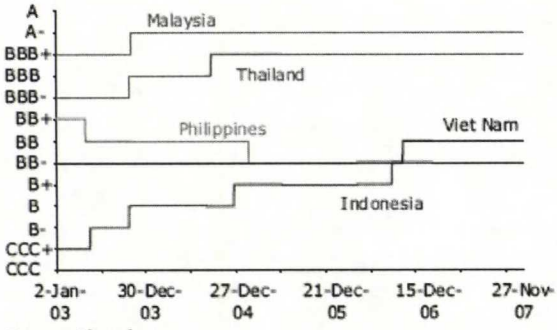
Bank of Korea: http://ecos.bok.or.kr/EIndex_en.jsp

People's Bank of China: http://www.pbc.gov.cn/english/diaochatongji/

Central Bank of the Republic of China (Taiwan):
http://www.cbc.gov.tw/EngHome/statistics.asp

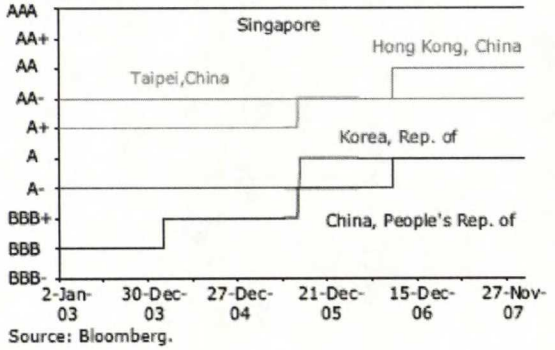
Annex 1

Figure 20a: **S&P Sovereign Ratings**
(Long-term foreign currency)



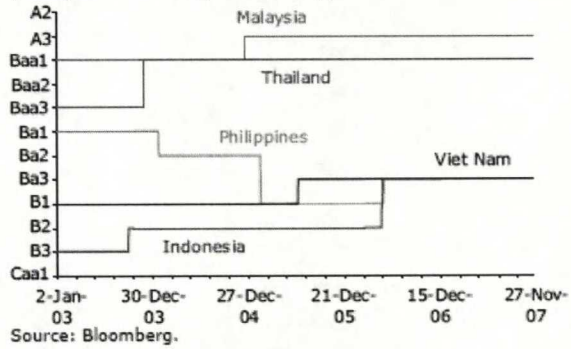
Source: Bloomberg.

Figure 20b: **S&P Sovereign Ratings**
(Long-term foreign currency)



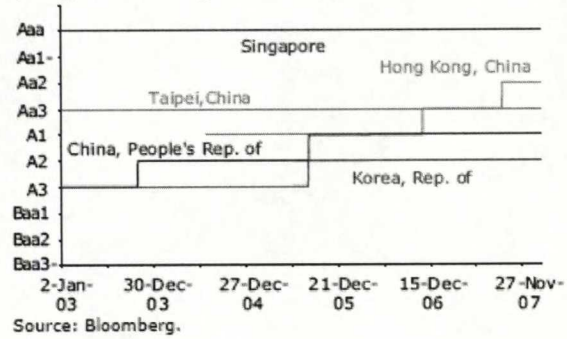
Source: Bloomberg.

Figure 20c: **Moody's Sovereign Ratings**
(Long-term foreign currency)



Source: Bloomberg.

Figure 20d: **Moody's Sovereign Ratings**
(Long-term foreign currency)



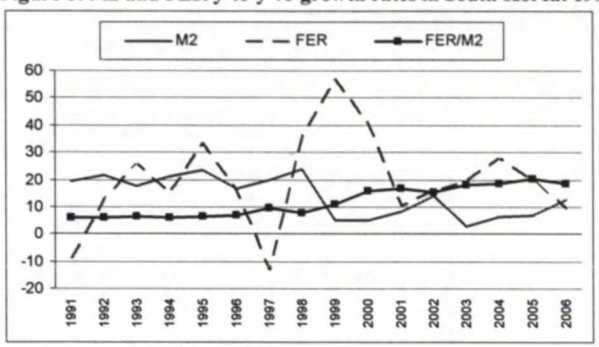
Source: Bloomberg.

Table 5: Ratings of Standard & Poor's and Moody's with prescriptions

S&P's	Moody's	Prescription of the group of ratings
AAA	Aaa	Substantially risk free. Exceptional financial security.
AA+ AA AA-	Aa1 Aa2 Aa3	Minimal risk. Excellent financial security
A+ A A-	A1 A2 A3	Modest risk. Good financial security
BBB+ BBB BBB-	Baa1 Baa2 Baa3	Average risk. Adequate financial security. Certain protective elements are lacking
BB+ BB BB-	Ba1 Ba2 Ba3	Acceptable risk. Questionable financial security, major uncertainties
B+ B B-	B1 B2 B3	Poor financial security. Currently has capacity but any adverse development will impact financial commitments negatively
CCC+ CCC CCC- CC C D	Caa Ca C	Very poor financial security, often in default or on the verge of default.

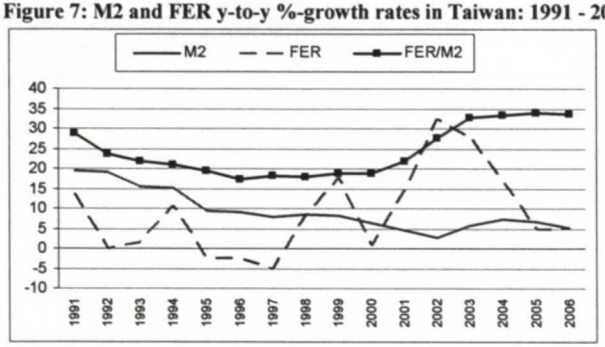
Annex 2

Figure 6: M2 and FER y-to-y %-growth rates in South Korea: 1991 - 2006



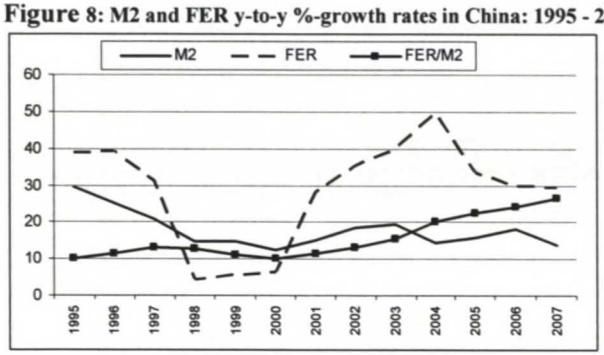
Source: Bank of Korea

Figure 7: M2 and FER y-to-y %-growth rates in Taiwan: 1991 - 2006



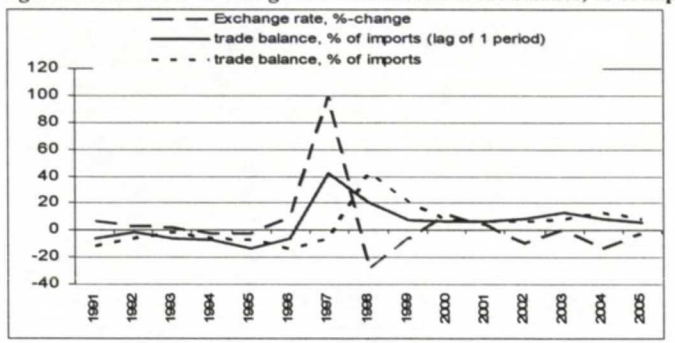
Source: Central Bank of the Republic of China (Taiwan)

Figure 8: M2 and FER y-to-y %-growth rates in China: 1995 - 2007



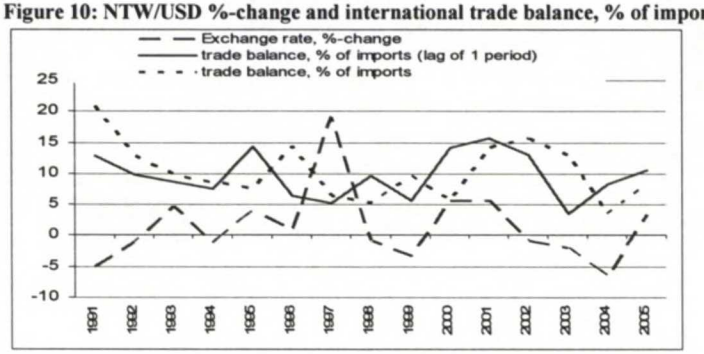
Source: People's Bank of China

Figure 9: KRW/USD %-change and international trade balance, % of imports: 1991 - 2005



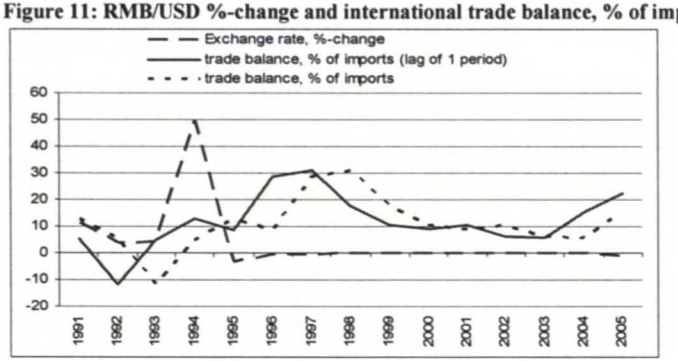
Source: Federal Reserve and UNCTAD

Figure 10: NTW/USD %-change and international trade balance, % of imports: 1991 - 2005



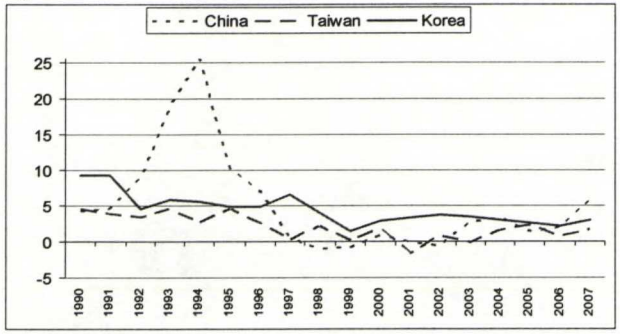
Source: Federal Reserve and UNCTAD

Figure 11: RMB/USD %-change and international trade balance, % of imports: 1991 - 2005



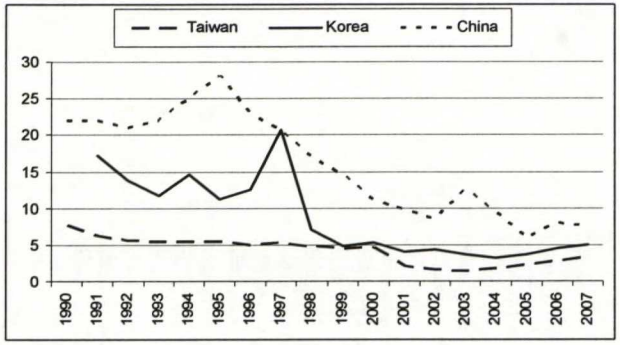
Source: Federal Reserve and UNCTAD

Figure 12: Inflation rates in China, Taiwan and South Korea: 1990 - 2007



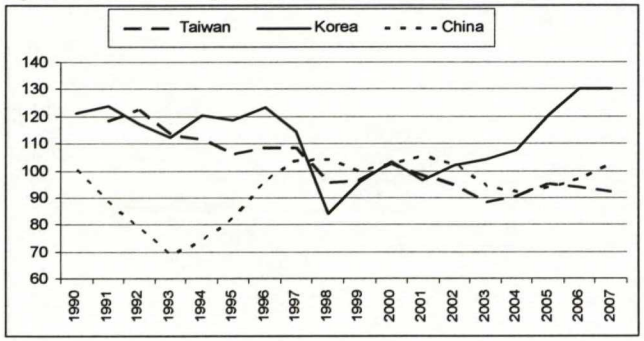
Source: IMF World Economic Outlook, October 2007

Figure 13: Interest rates: 1990-2007 (Taiwan: CB-rate; China&Korea: Interbank rates)



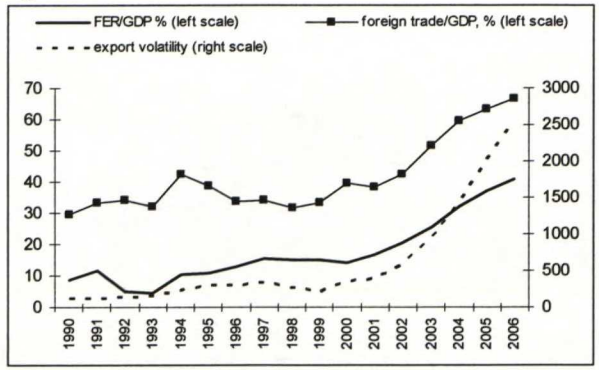
Source: OECD, Econstat

Figure 14: Real exchange rates (Taiwan 89=100; Korea&China 00=100)



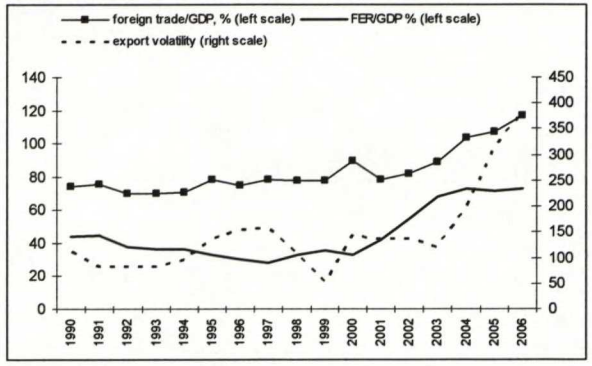
Source: ADB

Figure 15: China



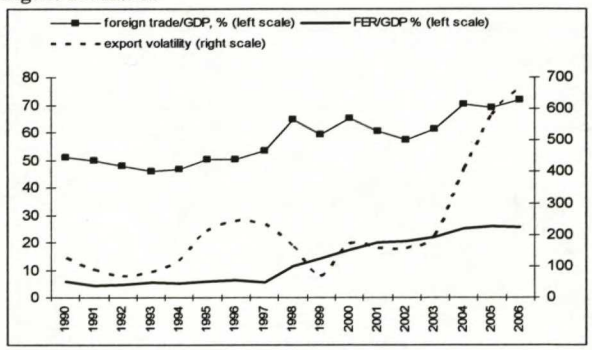
Source: IMF, author's calculations

Figure 16: Taiwan



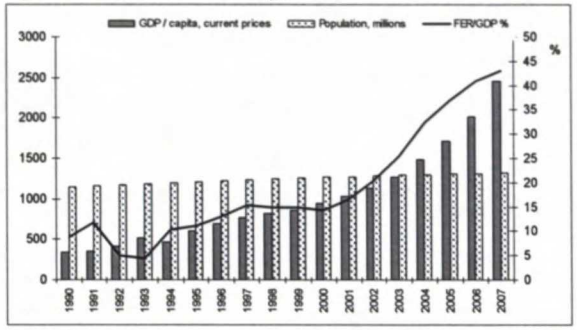
Source: IMF, author's calculations

Figure 17: Korea



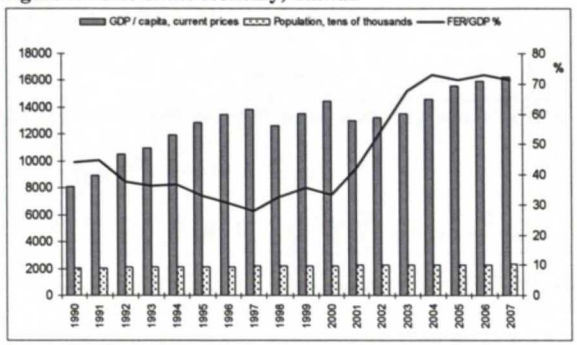
Source: IMF, author's calculations

Figure 18: Size of the economy, China



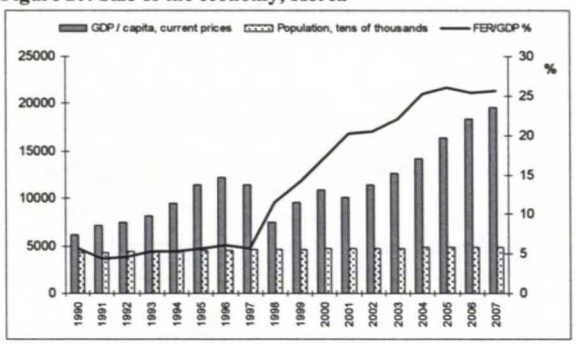
Source: IMF

Figure 19: Size of the economy, Taiwan



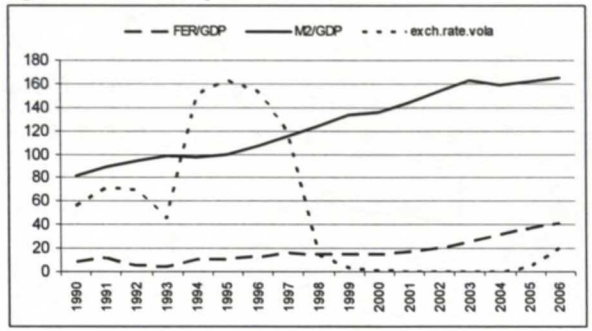
Source: IMF

Figure 20: Size of the economy, Korea



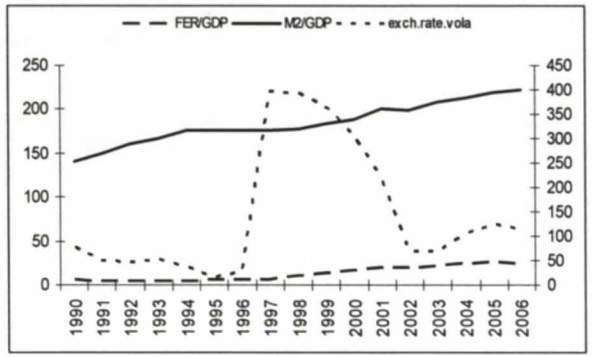
Source: IMF

Figure 21: Financial openness, China



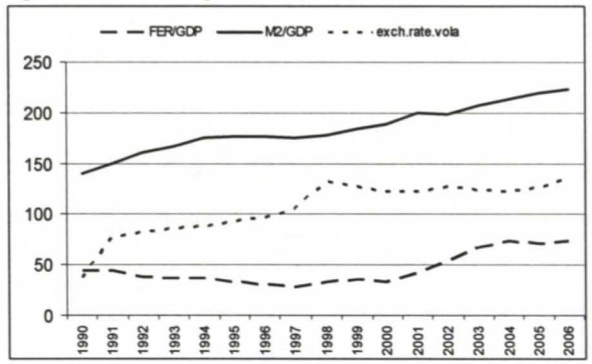
Source: ADB, author's calculations

Figure 22: Financial openness: Korea



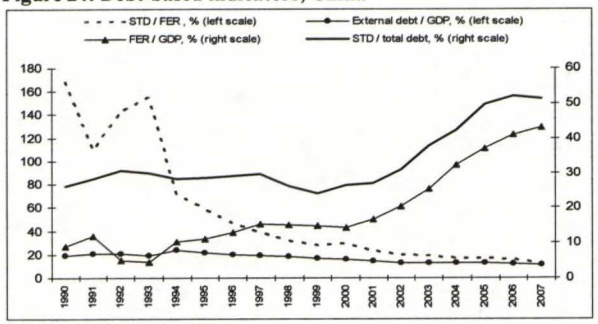
Source: ADB, author's calculation

Figure 23: Financial openness: Taiwan



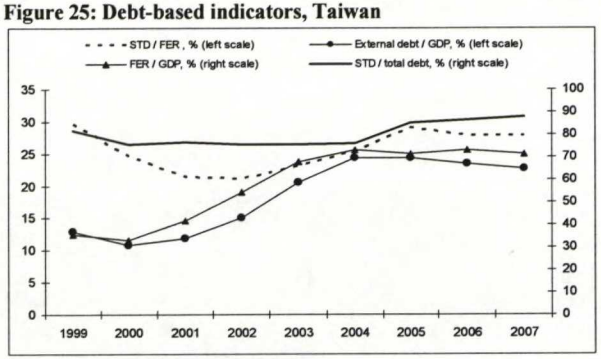
Source: ADB, author's calculations

Figure 24: Debt-based indicators, China



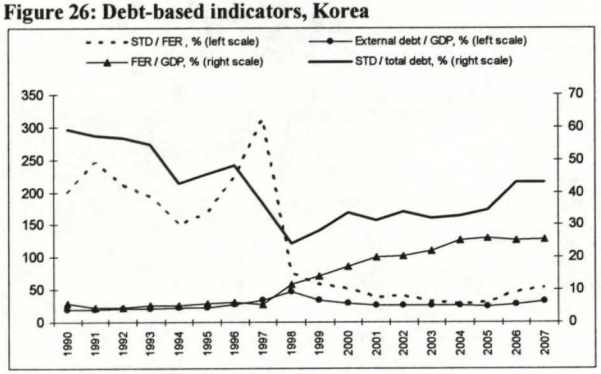
Source: ADB, author's calculations

Figure 25: Debt-based indicators, Taiwan



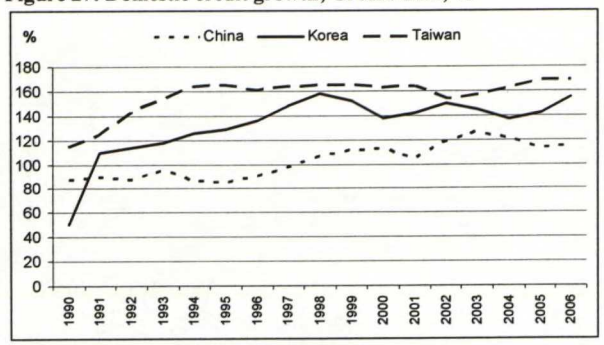
Source: ADB, author's calculations

Figure 26: Debt-based indicators, Korea



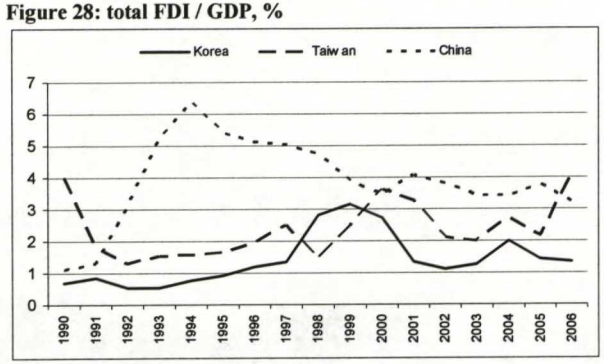
Source: ADB, author's calculations

Figure 27: Domestic credit growth; Credit/GDP, %



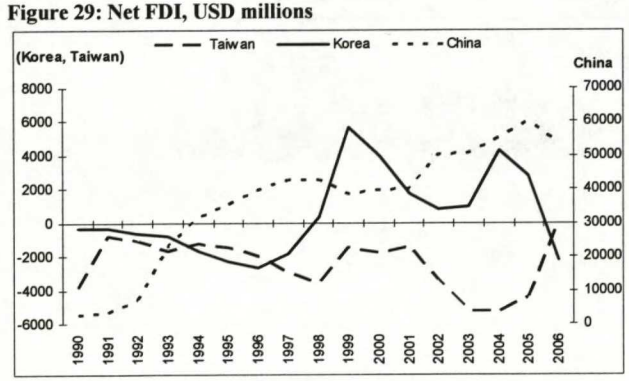
Source: ADB, author's calculations

Figure 28: total FDI / GDP, %



Source: ADB, author's calculations

Figure 29: Net FDI, USD millions



Source: ADB, author's calculations

Annex 3

Table 6: multiple regression models A, B, and C

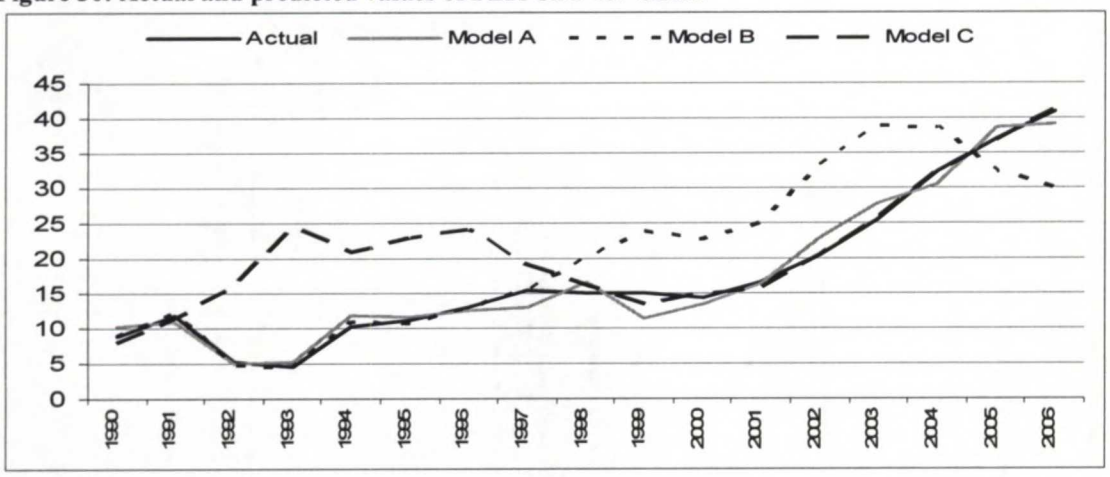
	(A) 1990–2006			(B) 1990–1997			(C) 1998–2006		
	coef	*t-stat*		*coef*	*t-stat*		*coef*	*t-stat*	
Constant	-287.548	-2.243	*	403.166	1.640		182.342	1.058	
CAB	1.195	3.202	***	0.802	1.486		-0.574	-1.025	
dummy CRISIS	-7.216	-1.299							
DOMCRE	10.733	1.969	*	-19.207	-1.583		-33.391	-1.997	*
EXCHRATE_VOLA	4.017	2.073	*	-7.164	-2.591	*	3.869	1.987	*
FDI_VOLA	0.912	2.610	*	0.777	1.532		0.476	0.789	
FT_GDP	0.079	0.289		-0.264	-0.931		-0.890	-2.127	*
LOGGDP_C	64.990	1.848	*	-131.035	-1.890		-19.716	-0.510	
M2_GDP	0.257	0.866		0.658	1.634		0.066	0.186	
REXCR	0.067	0.471		-0.099	-1.129		-0.225	-0.961	
STD_GDP	2.478	4.759	***	-0.965	-0.790		1.287	2.353	*
TED	-0.113	-1.471		0.342	2.135		0.012	0.150	

Source: Author's calculations

*** = p < 0,01 * = p < 0,1

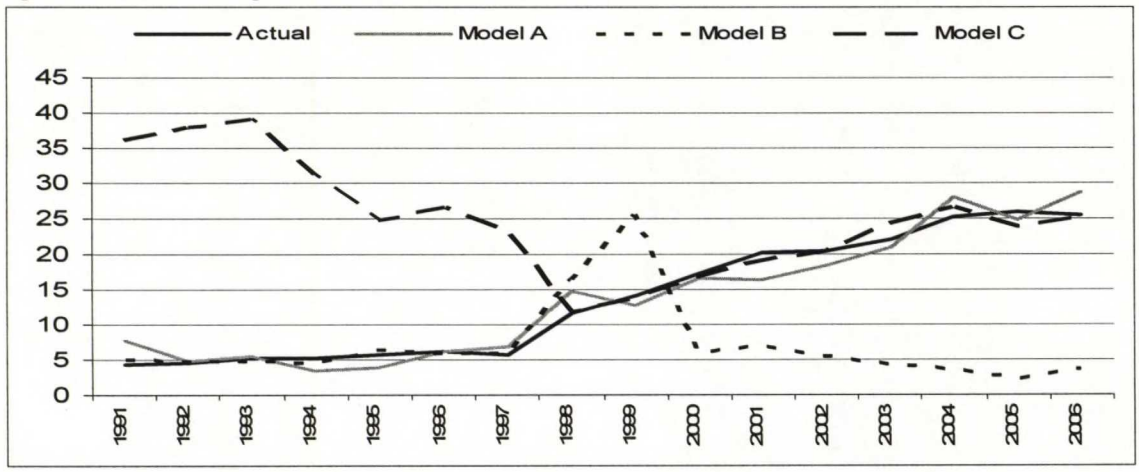
CAB = Current account balance
DOMCRE = Domestic credit
EXCHRATE_VOLA = Exchange rate volatility
FDI_VOLA = Foreign direct investment volatility
FT_GDP = Foreign trade to GDP –ratio
LOGGDP_C = GDP / capita (in logarithms)
M2_GDP= M2 / GDP –ratio
REXCR = Real exchange rate
STD_GDP = Short-term debt to GDP –ratio
TED = Total external debt

Figure 30: Actual and predicted values of FER/GDP for China



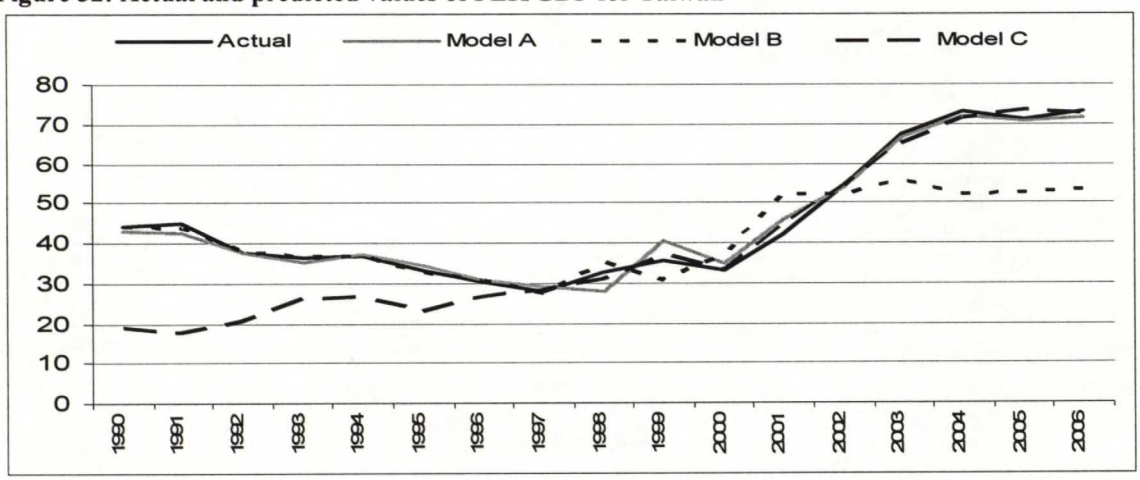
Source: Author's calculations

Figure 31: Actual and predicted values of FER/GDP for Korea



Source: Author's calculations

Figure 32: Actual and predicted values of FER/GDP for Taiwan



Source: Author's calculations